The role of materials in cryogenics

ASM

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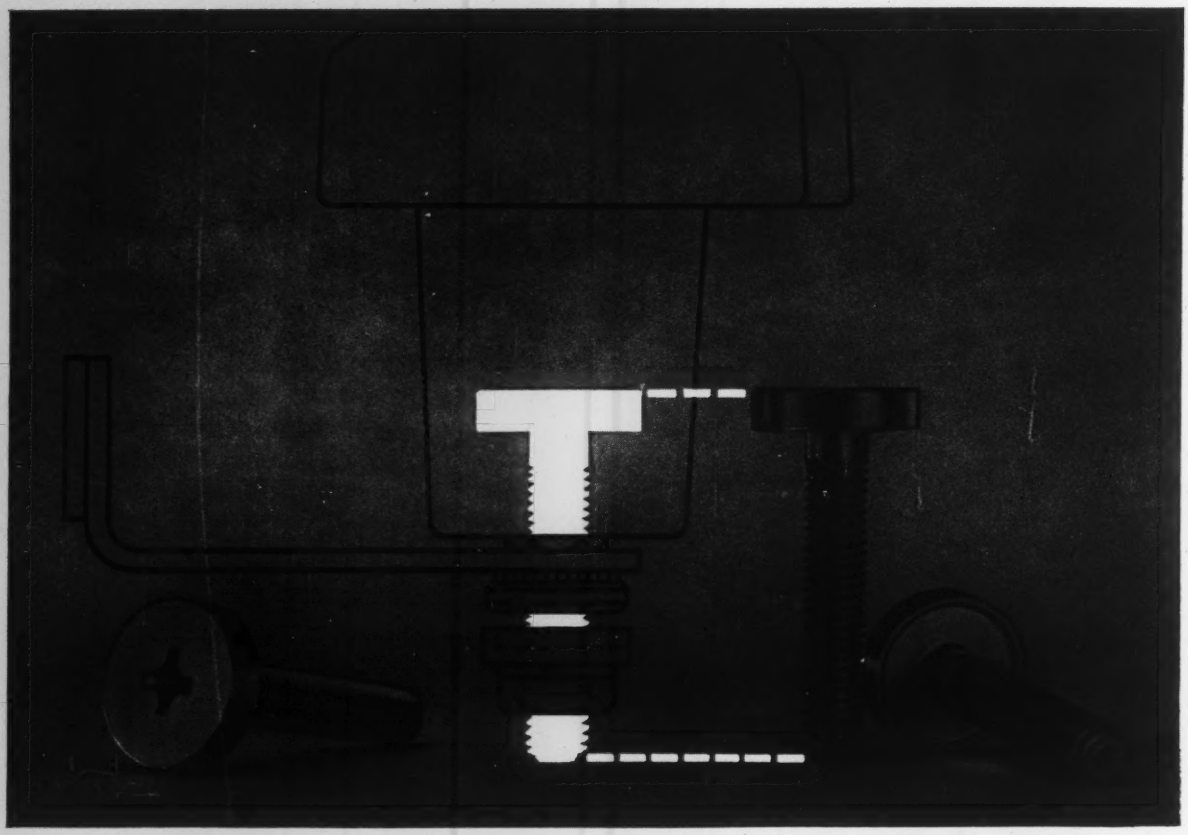
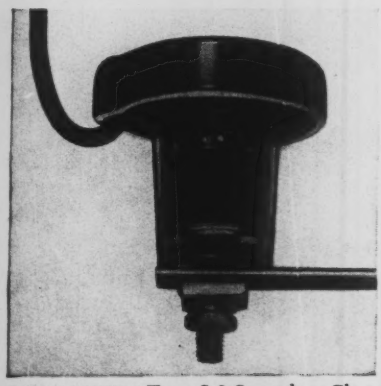


CUNISIL, new Anaconda copper-nickel-silicon alloy, gives you high strength for tough electrical jobs

THE PROBLEM: The studs for Line Materials Secondary Class Lightning Arresters (illustration above and below left) call for an unusual combination of properties. They must have high physical strength for structural reasons and to handle the stresses of high surge currents. Yet they must also have relatively high electrical conductivity. And for economical fabrication, the alloy must have good cold-forming characteristics and be readily machinable.



LINE MATERIALS Type S-3 Secondary Class Arrester with stud of Cunisil, copper-nickel-silicon alloy. Cunisil is also used for lower studs of Line Materials Protective Gaps.

THE SOLUTION: Continental Screw Company, which makes the studs for Line Material Industries, found the answer in Cunisil-837, Anaconda's versatile new high-strength, heat-treatable alloy with these valuable properties in the precipitation-hardened condition:

Tensile strength—psi min.	90,000
Yield strength—at .50% extension under load, psi min.	70,000
Elongation in 4 x D, min.	8%
Machinability, (Free Cutting Brass=100)	40
Electrical Conductivity, % IACS, as heat treated	30 to 42

In addition, Cunisil-837 has corrosion resistance comparable to copper and Everdur® copper-silicon alloys—and is easy to work cold before heat treatment.

METALLURGICAL COMMENT. Most of the nickel and silicon in heat-treated Cunisil is present as an intermetallic compound, nickel silicide, and it is the precipitation of nickel silicide in the form of particles of submicroscopic size by a relatively low temperature heat treatment that accounts largely for the distinctive properties of the alloy.

Prior to the hardening heat treatment, the alloy is brought to a proper condition for hardening with a solution anneal at a much higher temperature and then a water quench from this temperature; at this stage the alloy is quite soft and in a condition for drastic cold-working operations. The hardening heat treatment consists of heating at a controlled temperature for a definite length of time to obtain the desired mechanical properties.

For more information—see your Anaconda American Brass representative, or write: Anaconda American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6149

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Anaconda American Brass Company

JULY, 1961 | VOL. 54, NO. 1

Materials in Design Engineering®

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

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What's New in Materials

At a Glance 5

Heat Treated Alloy Steels Available as Structurals 9
Angles, I-beams, channels of four steels promise greater efficiency

Self-Extinguishing Urethane Foams 10
Flame resistance not dependent on additives that impair properties

Hot Wires Slice Plastics Foams 11
Urethane block cut into strips to form filter rings for autos

Titanium-Clad Steel 12
Composite plates are now being made without using an interlayer

Ablative Coatings Protect Parts at 3000 F 12
Refractory-filled phenyl silanes intended for rockets, missiles

One-Piece Refrigerator Liner Vacuum Formed from Polystyrene 13
Part molded from high impact sheet is 12 cu ft, weighs 15 lb

Zircaloy-2 Is Vacuum Hot Pressed 15
Parts are dense, isotropic, and can be held to close tolerances

Vinyl Coatings Give Multicolor Effects 139
Variety of patterns, colors achieved in two spray passes

Other Contents 15

Materials Engineering & Design

At a Glance 89

Why Did These Parts Fail? 91
Eight case histories of improper materials selection, fabrication

Three Prize Winning Metal Powder Applications 96
Brass powder used for five-part gear and cam train in fire alarm

Cut Your Costs with Bonded Fibrous Sheets 97
Used to simulate leather, in gaskets, as battery separators, etc.

Lightweight Ordnance Equipment 100
How the Army is using aluminum, magnesium, titanium, plastics

Other Contents 125

SPECIAL REPORT NO. 185 **The Role of Materials in Cryogenics** 107
What happens to metals and nonmetallics at −150 to −452 F

CONTINUED ON PAGE 3 →

Switching from aluminum to Zamak sliced casting costs in half on this Whitehead ball bearing bobbin holder. And with seven zinc die castings accounting for all the major working parts, overall costs dropped a neat 12%.

This high volume item is found on spinning frames in cotton mills—it's designed to take twenty to thirty years of rugged, day-in day-out service. Yet by using Zamak instead of aluminum, the wall thickness of certain parts was reduced from .065" to .050". This resulted in a decrease in material cost with no loss in strength. Whitehead Die Casting plans to bring their costs down still further by going to wall thicknesses of .032"—with the toughness of the parts still unaffected as far as their performance goes.

Besides the healthy cost savings directly related to the reduced wall sections, Zamak also provides Whitehead with a familiar success story—"faster and more economical production . . . longer die life . . . less rejects." Zamak gives you more for less — — —

WHITEHEAD BALL BEARING BOBBIN HOLDER

AWARD OF MERIT

THE NEW JERSEY ZINC COMPANY'S "DIE CASTING OF THE YEAR" COMPETITION

CASTING COSTS CUT 50%

are YOU getting your METAL'S WORTH?

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CONTINUED FROM PAGE 1

News of Industry

New Materials, Processes Discussed at Design Conference 17
ASTM Votes on Name Change 19
New Research Projects, Facilities 19
News of Societies 19
Coming Meetings 20

Reader Service

..... 37

Technical Literature

Suppliers' New Literature 39
Books 45
Reports 45

File Facts

Corrosion Resistance of Nickel Alloy Castings 121

Prices & Supply

At a Glance 123

The Last Word

Should They Take Off the Gloves? 172

Other Departments

Letters to the Editor 23
Advertising Indexes:
Products Advertised 170
Advertisers 170

NEXT MONTH

A New Look at Prefinished Metals . . .
A 12-page summary of what is available today in prefinished, precoated and mechanically patterned sheet and strip, and the advantages and limitations of using these materials.

How Materials Groups Help Build Appliances

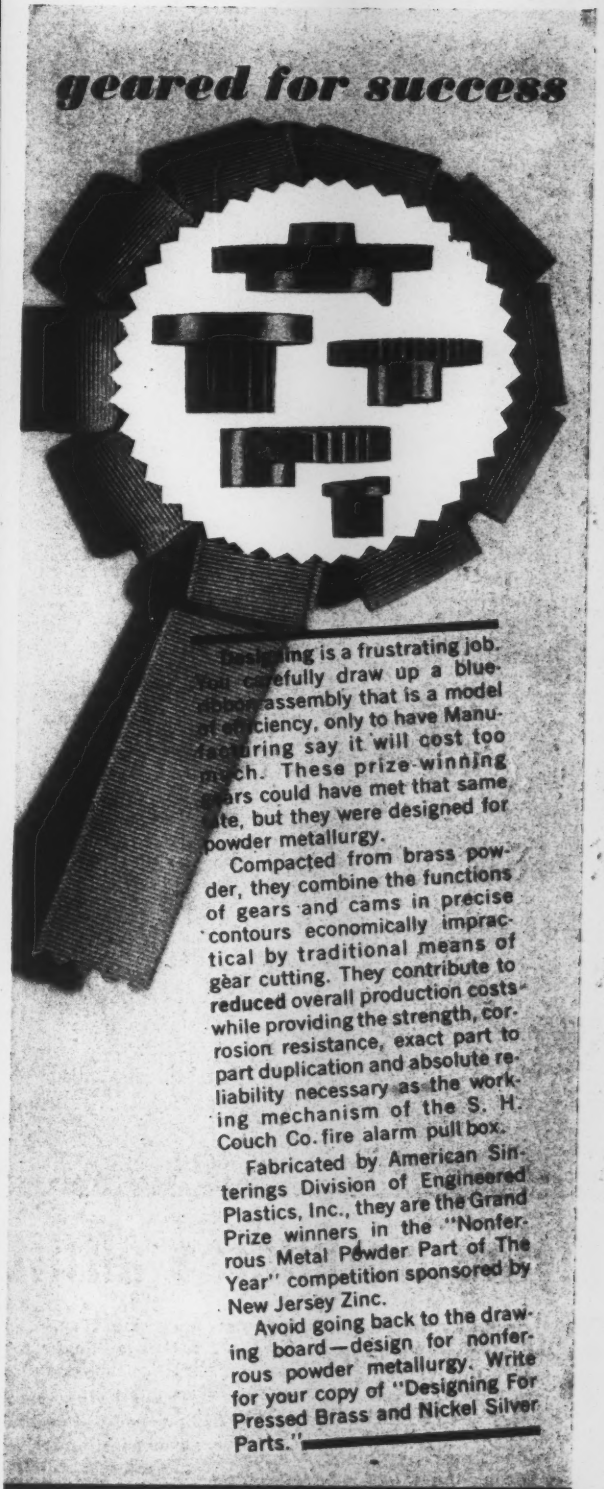
Injection Molded Ceramics

Solid-Film Molybdenum Disulfide Lubricants

High Temperature Materials Today and Tomorrow

How to Design an Adhesive Bonded Joint

This Month's Cover *by Harry & Marion Zelenko.*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powder metallurgy.
Compacted from brass pow-
der, they combine the functions
of gears and cams in precise
contours economically imprac-
tical by traditional means of
gear cutting. They contribute to
reduced overall production costs
while providing the strength, cor-
rosion resistance, exact part to
part duplication and absolute re-
liability necessary as the work-
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Couch Co. fire alarm pull box.
Fabricated by American Sin-
terings Division of Engineered
Plastics, Inc., they are the Grand
Prize winners in the "Nonfer-
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Avoid going back to the draw-
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Flying workhorse airlifts 80-foot power tower

Nickel in alloy steels gives 'copter transmissions extra strength for the toughest jobs

This Sikorsky S-58 is carrying a prefabricated tower to a power line construction project near Lynchburg, Virginia. After setting the towers in place, the 'copter saves time and money by helping to string wire from tower to tower.

Again, these flying workhorses prove they can handle the roughest assignments. But pilots don't want superlatives or guarantees. They want to know without doubt that critical parts will do their job. That's one big reason why nickel is alloyed into the S-58's transmission shafts and gears.

Nickel helps steel take the tremendous bending and twisting of a 'copter's drive shaft under powerful shock loads and unusual conditions.

Strength and toughness are only two properties that nickel imparts to alloys. It can help them withstand the intense heat generated by supersonic flight . . . or shrug off the intense cold of liquid helium. It also offers outstanding corrosion resistance.

When you have a metal problem, don't hesitate to call us. Nickel or one of its alloys may provide the answer.

THE INTERNATIONAL NICKEL COMPANY, INC.

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INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

New decorative effects for metals have been achieved by using colored electroplated coatings over textured metal surfaces. When textured steel is zinc plated and dyed with chromate conversion coatings, buffing causes the bright zinc to stand out in relief against the colored chromate conversion coating in the recesses.

Source: Metal & Thermit Corp., Plating Div., Rahway, N. J.

A high temperature nylon fiber has been developed. The new fiber shows promise for such applications as electrical insulation, filtration of hot gases, special-duty belting, and reinforcement of high temperature hose. A pilot plant for production of the fiber is scheduled for completion late in 1962.

Source: E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Three improved epoxy foams provide high tensile, flexural and compressive strengths, excellent dimensional stability and dielectric properties, and a wide range of predictable and controllable densities. They are: 1) a liquid foam-in-place system, 2) a powdered resin for high temperature use, and 3) a post-formable foam which can be shaped by heating. Cost is about the same as that of urethane foams of comparable density. (More details next month.)

Source: The Boeing Co., Wichita Div., Wichita, Kan.

Another epoxy foam insulation can now be sprayed. The sprayable material is a modification of an epoxy foam developed for low temperature insulation use (M/DE, Mar '61, p 120). A major benefit claimed in comparison with urethanes is lower toxicity; thus less elaborate personnel protection is required during spraying.

Source: Shell Chemical Co., 110 W. 51st St., New York 20.

Deposits from a new gold electroplating process are said to meet the most exacting finishing specifications required for transistors and other electronic parts. Gold deposits are 99.99%+ pure, extremely ductile, and harder than conventional gold deposits. Electroplates up to 0.003 in. can be produced under ordinary operating conditions, according to the developer.

Source: Sel-Rex Corp., 75 River Rd., Nutley 10, N. J.

Lower cost electroformed parts of nickel and copper are being turned out by a new process that is said to virtually eliminate costly machining operations on finished parts. Ordinary electroforming techniques usually produce parts that require final machining to get rid of excessive metal buildup on edges.

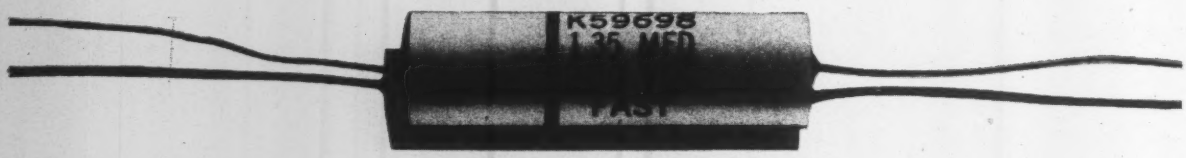
Source: Melpar, Inc., 3000 Arlington Blvd., Falls Church, Va.

A tougher cellular polyethylene has resulted from successful expansion of a high density resin (0.950 specific gravity). Aimed chiefly for use as thin-walled primary electrical insulation, the foam is said to have uniform cell size, along with the excellent electrical insulating properties of previously available expanded low density poly-

B.F.Goodrich

"Quality assurance"

and lower costs, too



with tubes of rigid Geon

FAST tubular capacitors encased in tubes made of rigid Geon are manufactured by John E. Fast Company, Chicago. Picture shows test operation. Special attention is paid to humidity, even to the clothes and cosmetics operators wear. 100% of production is tested to provide constant information on product quality. Tubes are extruded by Pyramid Plastics, Chicago, of rigid Geon supplied by B.F.Goodrich Chemical Company.

Because his capacitors are used in "Minuteman" missiles, this manufacturer pays extra attention to already high standards for reliability. He aims to a quality level 50 times better than normal industry goals. Maintaining this kind of quality can be costly. Instead, careful analysis of components which led to replacing paperboard tubes with tubes of rigid Geon vinyl helped improve reliability and cut costs at the same time.

The rigid Geon tube gives excellent dielectric characteristics. It assures that the case will never be the cause of a humidity problem. It will not corrode or be adversely affected by aging. The manufacturer has also found that rigid Geon tubing is easy to work with in assembly operations.

Here's another place where Geon vinyl is improving products, sometimes opening whole new markets. To learn about this and applications of Geon in other forms, write Department NN-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

Geon VINYLS

B.F.Goodrich Chemical

a division of The B.F.Goodrich Company

For more information, turn to Reader Service card, circle No. 337

ethylenes. The new material has a dielectric constant of 1.5 to 1.7, a tensile strength of about 2800 psi, and an elongation of about 300%. (More details next month.)

Source: Union Carbide Plastics Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17.

Plastics films can be sealed ultrasonically in thicknesses from ¼ mil to 100 mils at speeds up to 100 fpm. The ultrasonic device, which can also be used on synthetic fabrics, seals through contaminants such as grease, powders, paints and printing ink. It will not burn plastics or fabrics if the flow of material is interrupted.

Source: Ultra Sonic Seal, Inc., Div. of Kleer-Vu Industries, Inc., 76 Madison Ave., New York 16.

Less brittle wax coatings can be obtained by using new vinyl resins that are said to impart toughness, flexibility and adhesion to paraffin wax and other brittle, low molecular weight materials. The resins are copolymers of ethylene and vinyl acetate. Introductory price is 55¢ per lb.

Source: E. I. du Pont de Nemours & Co., Inc., Electrochemicals Dept., Wilmington, Del.

Injection moldable silicones may be coming along in the next few years. Several silicone copolymers have been synthesized which are thermoplastic, with softening points ranging from 285 to 525 F. Materials have already been experimentally injection molded in the laboratory. Strengths are moderate, as would be expected with silicones. Stumbling block at present appears to be obtaining reproducible high molecular weights.

Source: Mellon Inst., 4400 5th Ave., Pittsburgh 13.

A new magnesium oxide ceramic has been developed. Chief advantage of the translucent ceramic is its high strength and high density: when chemically polished, it has a tensile strength of 45,000 psi, compared to 24,000 psi for conventional magnesium oxide. The developer says density of the material "comes within 2% of the maximum density possible for magnesium oxide." The ceramic has a melting point of 5100 F.

Source: Minneapolis-Honeywell Regulator Co., 2954 4th Ave. S., Minneapolis 8, Minn.

Seamless stainless steel tubing with ultra-thin walls is now available. Wall thicknesses are 0.0005 in. with tolerances of ±0.00005 in. The thin-wall steel tubing is sold in outside diameters ranging from 0.010 to 0.375 in.

Source: Uniform Tubes, Inc., Collegeville, Pa.

New extruded rubber sealers are said to give positive sealing of uneven and tapered joints and excellent sealing around corners because of a unique cross-sectional "double doughnut" design. The sealers are supplied in hollow and solid forms. Both types of sealers are said to have excellent moisture, salt spray and weather resistance.

Source: Minnesota Mining & Mfg. Co., Adhesives, Coatings and Sealers Div., 900 Bush Ave., St. Paul 6, Minn.

A fast, economical way to join plastics pipe is by using a new "butt fusion" technique. Two lengths of pipe are aligned and an aluminum plate heated to 400 F is inserted between them. After the pipe ends soften, they are pressed together to form a joint that is reportedly stronger than the rest of the pipe. The operation takes 30 sec.

Source: Phillips Petroleum Co., Bartlesville, Okla.

Turn to page 9 for more "What's New in Materials"

controlled microstructure eliminates extra finishing

High production items like these wrench sockets require steel of uniform chemistry, structure and hardness. SNAP-ON TOOLS CORPORATION specifies Aristoloy 8630. They report that uniform quality and predictable machinability mean less down-time for tool changes and the elimination of extra finishing operations.

Aristoloy *electric furnace* steels are no accident. They result from controlled melting of selected scrap, careful rolling, and precise heat treating. Bars and billets produced are of controlled hardness and microstructure.

Call your local Copperweld representative for complete information—or write for PRODUCTS and FACILITIES CATALOG.

ARISTOLOY STEELS

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ARISTOLOY STEEL DIVISION 4021 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

For more information, turn to Reader Service card, circle No. 347

Heat Treated Alloy Steels Available as Structurals

For the first time, you can use quenched and tempered alloy steel structural shapes in your designs.

HOW THEY'RE MADE

Special fixtures (top) clamp structural shapes to prevent distortion during water quenching. Huge furnace tempers alloy shapes after quenching to reduce residual stresses.

■ Four alloy steels—T-1, T-1 Type A, 9% nickel and HY-80—are now commercially available for the first time in quenched and tempered structural shapes. The alloy steel structurals cost more than similar carbon steel structurals but the advantages gained are said to far outweigh the cost increase. Potential applications include such things as portable drilling rigs, bridges and cryogenic structures.

Spend more, save more

According to the U. S. Steel Corp., Pittsburgh, Pa., use of the heat treated structurals may result in cost reductions of up to 30%. Two reasons for the high cost reduction potential:

1. It will no longer be necessary to cut and weld quenched and tempered plate into structural shapes.

2. The higher mechanical properties of the alloy steel shapes will allow designers to reduce the weight of their structures. (T-1 steel, for example, has a minimum yield strength of 100,000 psi, about three times that of structural carbon steel.)

Range of sizes available

Lengths of the standard I-beams, angles and channels can range up to 40 ft. Specific sizes available are:

I-beams: American Standard Sections B-8 through B-14.

Channels: American Standard Sections C-1 through C-7.

Angles: Equal angle shapes are available from 3 × 3 in. to 8 × 8 in. Unequal angles range from 3½ × 3 in. to 8 × 6 in. Various thicknesses can be furnished in each basic size. KEY NO. 600

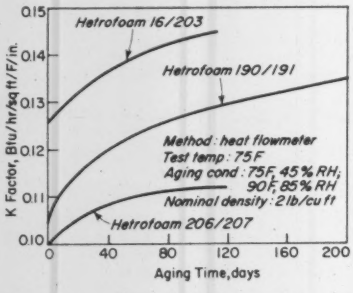
Self-Extinguishing Urethane

Now chlorine-containing polymers offer

- *Low and stable k factor*
- *Cost comparable to polyether systems*
- *Good heat resistance*
- *One-shot or prepolymer*

■ A new series of self-extinguishing rigid urethane foams is intended primarily for low temperature thermal insulation. Available as either one-shot or prepolymer systems, the materials are fluorocarbon-blown polyester systems, yet are said to be competitive in price with fluorocarbon-blown polyether rigid foam systems. Certain of the new foams can maintain k factors in the range of 0.10 to 0.12 Btu/hr/sq ft/°F/in. on aging.

Developed by Durez Plastics Div., Hooker Chemical Corp., and called Hetrofoam, the materials owe their self-extinguishing characteristics to a high chlorine content built into the polymer. Thus, additives, which may impair physical properties, are not required.



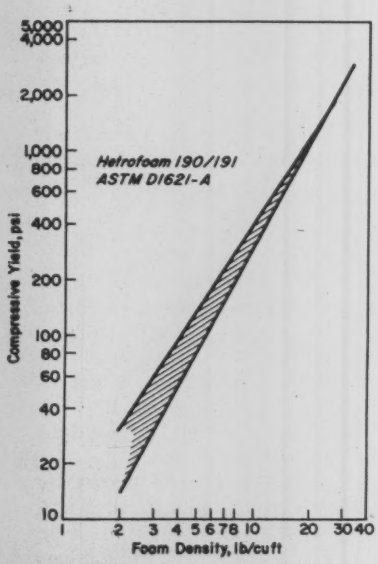
1—Effects of aging on k factor of the three types of foams. All specimens were cut producing exposed surfaces.

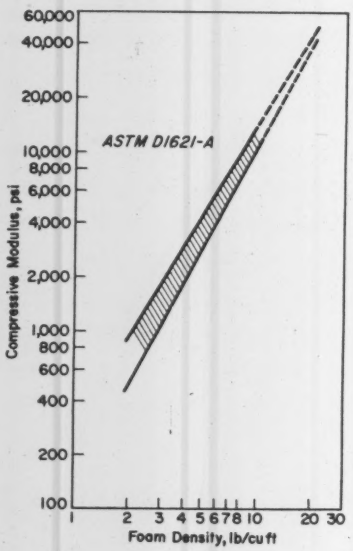
Potential applications for the foams include all areas of refrigeration: home refrigerators and freezers; refrigerated trucks, trailer and railroad cars; industrial and residential buildings; and piping. Other possible uses: flotation, core materials for structural sandwich panels, and radomes.

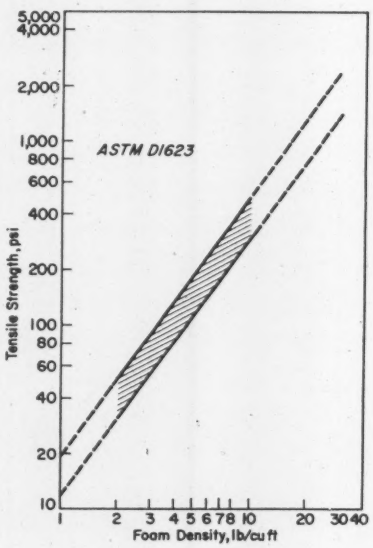
Four types available

Four basic systems are available:

1. Hetrofoam 206/207, a general purpose type of low density and low, stable k factor—primarily intended for optimum thermal insulation.
2. Hetrofoam 250, a one-shot system with properties similar to those of 206/207, but with lower burning rate (see table).
3. Hetrofoam 16/203, a high rising low density foam—intended







2—Density vs . . .
. . . compressive yield strength *. . . compressive modulus* *. . . tensile strength*

Foams

primarily for foam-in-place fabrication of panels up to 8 ft high.

4. Hetrofoam 190/191, a system with minimum density—adaptable to production of slab stock.

Properly controlled, these four systems can provide a range of foams with a variety of properties. The accompanying table shows typical properties of four different types of foams producible with these basic foaming systems. In addition to the self-extinguishing characteristics the foams have relatively good heat resistance, and low moisture absorption.

Fig 1 shows effects of aging on k factor of three of the basic foam systems. Note the stability of the 206/207 system (which is also said to be true of the one-shot system) making it particularly adaptable to refrigerator insulations.

Structural capabilities are indicated in Fig 2, curves showing effects of density on compressive yield strength, compressive modulus and tensile strength for a representative foam. KEY NO. 601

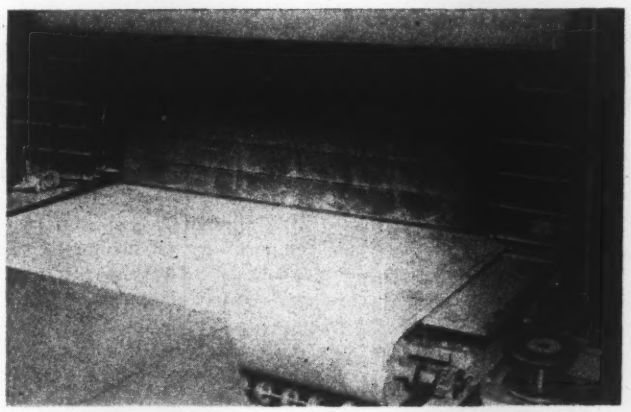
TYPICAL PROPERTIES OF FOUR REPRESENTATIVE HETROFOAM SYSTEMS

Type →	General Purpose[a]	Slab Stock	High Density	High Rise
Density, lb/cu ft	2.0	1.9	6.0	2.2
Compr Yld Str, psi				
At 77 F	31	26	135	23
At 212 F	28	14	100	18
Compr Mod, 1000 psi	1.13	0.81	5.2	0.64
Ult Ten Str, psi	55	38	220	35
Ult Shear Str, psi	24	23	67	20
Shear Mod, psi	600	460	1930	515
Ult Flex Str, psi	50	58	200	40
Cell Structure	Essentially closed	Essentially closed	Essentially closed	Essentially closed
Ther Cond (k factor; initial at 70 F), Btu/hr/sq ft/F/in.	0.100	0.105	0.120	0.130
Flammability				
ASTM D1692	Self-extinguishing	Self-extinguishing	Self-extinguishing	Nonburning
ASTM D757, ipm	0.75, 0.37[b]	0.49	0.47	0.26
UL Bulletin, Subject 94	Pass	Pass	Pass	Pass
Dielec Str, v/mil				
Short Time	147	121	34	75
Step-by-Step	>131	100	72	71
Dielec Const (1000 cps)	1.2	1.2	1.3	1.2
Power Factor (1000 cps), %	0.33	0.32	0.51	0.94

[a]Available in one-shot, as well as prepolymer systems.
[b]Lower value is for one-shot system, Hetrofoam 250.

Hot Wires Slice Plastics Foam

into strips for auto air filters



A block of foamed polyurethane plastic is shown being pressed against hot nickel-chromium wires that slice it into sheets.

A second set of wires then cuts the sheets into ¾-in. wide strips. The ends of each strip are cemented together to form a filter ring for use in an automobile engine air filter.

Polyurethane foamed plastic is an excellent filter because it is filled with twisted pores whose walls are wet with a nondrying oil that captures airborne dust particles.

The filters, produced by AC Sparkplug Div., General Motors Corp., are used in both Buicks and Corvairs.

Titanium-Clad Steel

made without an interlayer is available in developmental quantities

■ Cladding titanium to steel plate cuts the cost of using titanium by 25% and reduces forming problems at the same time, it is claimed. Potential applications of the new composite include reactors, pressure vessels and tanks for the process, chemical and petroleum industries.

Costly step eliminated

Research workers of Lukens Steel Co., Coatesville, Pa. have been working with titanium-clad plate for a number of years in order to reduce impurities and brittleness. Previous production methods required the use of an expensive vanadium or silver foil interlayer between the titanium and steel to produce fabricable material.

The Lukens technique uses the old roll bonding technique in which a four-deck pack of two layers of titanium sandwiched between two plates of backing steel is hot rolled. The rolling metallurgically bonds the titanium to the steel. A parting compound between the titanium plates makes it possible to separate the pack into two clad plates after rolling.

The problem of cleanliness and freedom from impurities of both the steel and titanium surfaces makes production of titanium clad plate different from other cladding operations. Lukens solved the problem by purging and flushing the pack with argon gas during the 6 to 10-hr preheat before hot rolling.

Developmental only

Titanium-clad plate is not a standard production item and Lukens is taking orders only on a development basis.

Maximum titanium cladding is 3/16 in. on plates up to 1¼ in. thick. Plates run 4 to 8 ft wide and 12 to 24 ft long. **KEY NO. 602**

Ablative Coatings Protect Parts at 3000 F

Refractory-filled phenyl silanes intended for nose cones, rocket motor cases and missile components.

■ Two ablative coatings have recently been developed by U. S. Polymeric Chemicals, Inc., Canal and Ludlow Sts., Stamford, Conn., for protecting parts over a wide temperature range. The coatings provide protection at low heat levels through a combination of insulation and resistance to thermal decomposition; additional protection is provided at higher heat fluxes through ablative action.

Because of their heat resistance the coatings are expected to be useful in protecting such equipment as rocket motor cases, nose cones and aircraft components. Because of their chemical resistance the coatings can also be used where high temperature corrosion resistance is required.

Two temperature ranges

The two coatings are intended for different temperature ranges. Both grades contain heat resistant phenyl-silane thermosetting resins; however, they differ in the type of refractory filler used (the fillers are proprietary compounds). One grade (CT-803) is recommended for conventional insulation applications where temperatures do not exceed 3000 F (typical properties of this grade are shown in the accompanying table). The second grade (CT-804) contains a different filler which provides better protection at temperatures above 3000 F.

TYPICAL PROPERTIES OF ABLATIVE COATING*

Ther Cond, Btu/hr/sq ft/°F/ft	
200 F	0.113
300 F	0.132
400 F	0.109
500 F	0.115
Coef of Lin Exp, 10^{-6}/°F	
100 F	26.2
200 F	25.55
300 F	28
400 F	27.35

*CT-803.

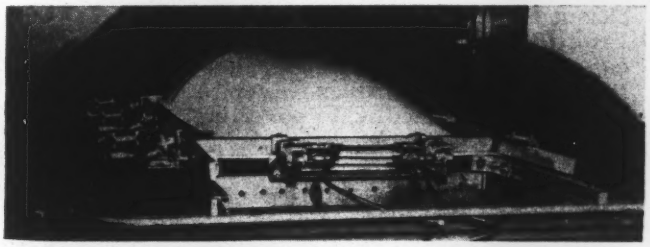
Application requires heating

Application differs from that for conventional organic coatings in that the base metal must be heated both during and after application. After thorough cleaning, the part is heated to about 220 F. While the metal is still hot the prime coat is applied as thin as possible (usually 2 to 4 mils) by conventional painting techniques—brush, roller or spray gun. After application the prime coat is kept at 200 F until it reaches a tack-free, semicured condition; this usually takes 10 to 15 min.

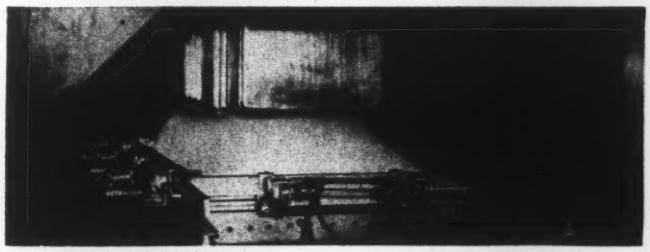
The second coat and all subsequent coats can be applied in thicknesses up to 10 mils and must be dried at 200 F. After the desired thickness has been reached temperature is gradually raised (about 10 °F per hr) up to 350 F and the part is cured at this temperature for 1 hr. After curing, the coating may be sanded or ground to the proper thickness and polished to a smooth aerodynamic surface. **KEY NO. 603**

One-Piece Refrigerator Liner Vacuum Formed from Polystyrene

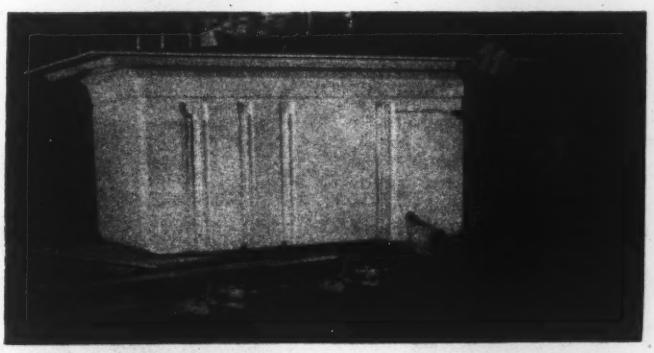
1. Positioning sheet plastic, *formed from polystyrene pellets, in the rotary forming machine where it is first heated to 160 F.*



2. Inflating the hot sheet *in the vacuum forming mold with compressed air. A photoelectric cell shuts off the air when the bubble reaches the desired height.*



3. Lowering the top platen *into the bubble. A vacuum draws the polystyrene into all corners of the mold. The formed liner cools for about 1 min before it is removed from the mold.*



4. Removing the liner *from the press. Support rails and grooves for shelves, pans and drawers, and the evaporator frame and mounting bosses, are integrally molded.*

Refrigerator liners that serve both as insulators and structurally as shelf supports are now being vacuum formed in one piece from polystyrene sheet.

The new liner, produced by The Midwest Manufacturing Corp., subsidiary of Admiral Corp., is about 46 in. × 23 in. × 20 in. Wall thickness is 0.1 in. and the liner weighs 15 lb.

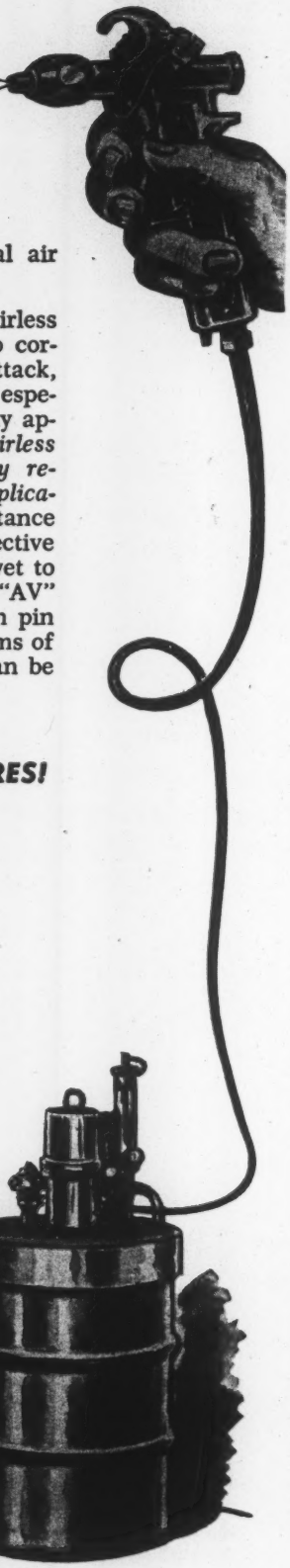
High impact polystyrene liners are said to offer several advantages over enameled metal. They are: rust and chip proof; have no unsightly and unsanitary joints; are excellent thermal insulation; and are easily formed and require less handling in assembly operations.

Here are the major steps in forming the large unit from Dow Chemical Co.'s Styron 475 sheet.

5. Inspecting the liner's *complex interior shape.*

TYGON® *Airless* VINYL

Cuts painting costs 30% to 50%



Airless spraying of protective coatings is based on the principle that liquid forced under pressure through a restricted opening tends to atomize. The garden hose and shower head are homey examples. A few years ago, it was found that paint forced through a specially shaped nozzle at pressures of 1000 psi or more, broke into millions of particles and could be deposited like a fine mist on surfaces to be painted. This new spray process made possible the use of heavier-bodied coatings with less solvents; it eliminated material "bounce-back"; it reduced overspray to a minimum. In application after application, material and labor costs were cut anywhere from 30% to 50% over normal air spray methods.

Practically any paint can be airless sprayed. But where resistance to corrosive fumes, acid and alkali attack, are involved, it takes a coating especially formulated for airless spray application to do the job. *Tygon Airless Vinyl (Series "AV") meets every requirement for airless spray application,* plus offering corrosion-resistance properties unmatched by any protective coating. Possessing exceptional wet to dry film homogeneity, Series "AV" builds a protective film free from pin holes, even in thin films—and films of virtually any desired thickness can be built in a single application!

CHECK THESE MONEY-SAVING . . . SURFACE-SAVING FEATURES!

UNMATCHED CHEMICAL RESISTANCE

Resists acids, alkalies, oils, greases, water and alcohols

ANY DESIRED FILM THICKNESS

Up to 20 mils or more dried film if desired, but rarely are more than 6-10 mils required

DRIES QUICKLY

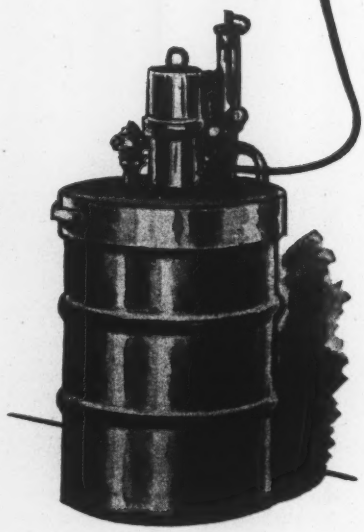
Series "AV" dries to touch in 10-15 minutes

LONG SHELF LIFE

Solids remain in suspension. Minimum agitation required.

LOWEST APPLIED COST

Savings up to 30%-50% in labor and materials. Tygon AV Series vinyl can be applied to a 5 to 7 mil thickness in a single coat using conventional spray equipment.



For full information write for Technical Data Sheet "AV"

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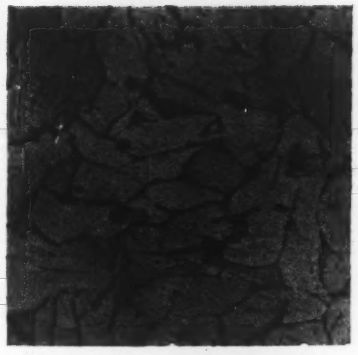
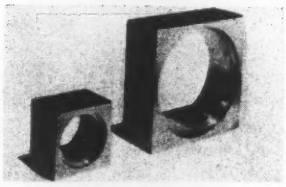


CONVENTIONAL PRESSED AND SINTERED

VACUUM HOT PRESSED

Zircaloy-2 Is Vacuum Hot Pressed

Parts are dense, isotropic, accurate



***Zircaloy-2** parts produced by vacuum hot pressing. Use of parts is classified.*

■ A vacuum hot pressing technique is being used commercially by the Metallurgical Products Dept., General Electric Co., Detroit to produce Zircaloy-2 components. The process—which simultaneously hot presses and sinters a component—can also be used with the refractory metals and their carbides.

The process has three significant advantages:

1. Because parts are hot pressed and sintered at the same time, shrinkage is not a problem. Parts can therefore be designed which require little or no machining. Even special shapes can be held to close tolerances.

2. Density is extremely high. The Zircaloy-2 part shown in the accompanying photograph has a density of 6.57 gm per cu cm, or 100% of theoretical. The high degree of densification is reflected in the microstructure (see photomicrograph).

3. Properties are isotropic, or nondirectional. Designers, therefore, do not have to compensate for directional weakness.

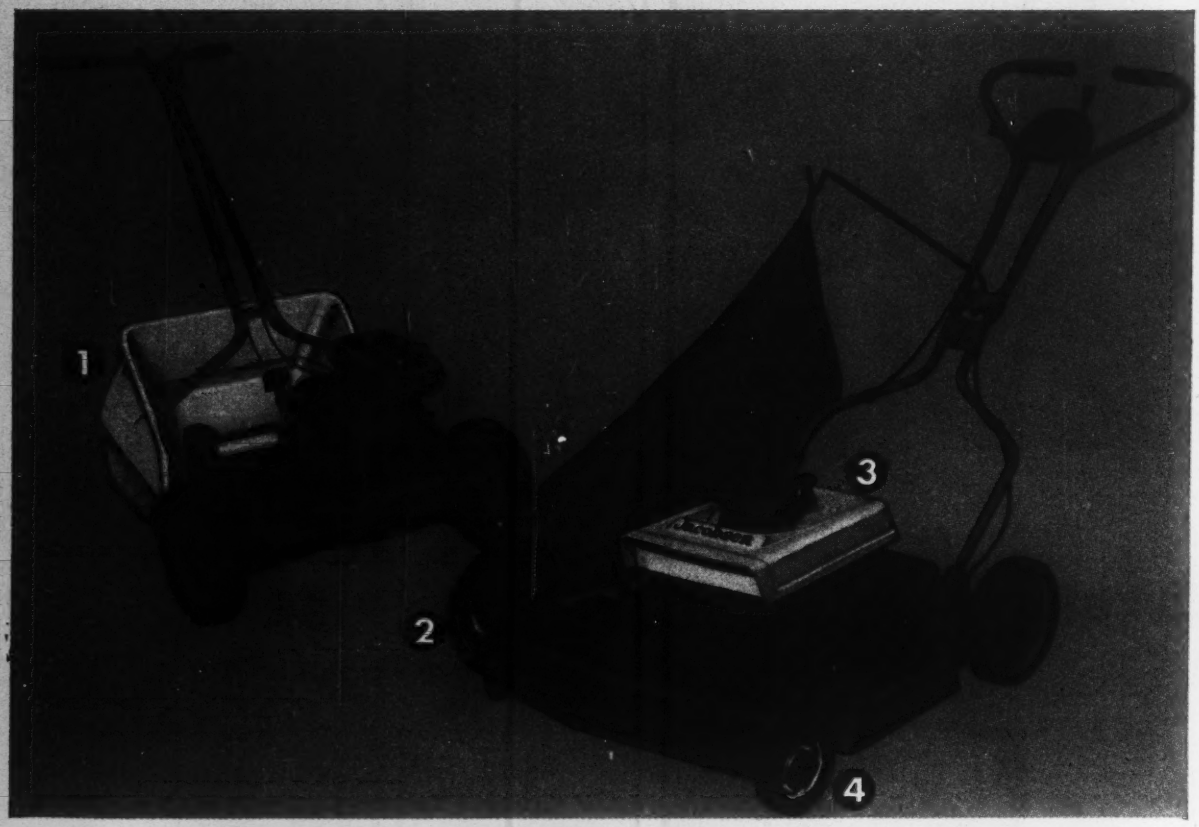
Nuclear, chemical uses

As a material used in the nuclear industry almost since its inception, Zircaloy-2 has many well-known properties such as low neutron cross section, resistance to corrosion in high temperature steam, etc. Vacuum hot pressed Zircaloy-2 will meet all nuclear specifications, including Navy MIL-Z.

Not so well known, but still of interest, is the material's potential for chemical applications. According to General Electric Co., at room temperature Zircaloy-2 will resist attack by most organic acids, nitric acid, sulfuric acid and, to some extent, hydrochloric acid. Resistance to alkaline solutions is also good. KEY NO. 604

MORE WHAT'S NEW IN MATERIALS

Vinyl coatings give multicolor effects 139
Tool and die steel 139
Silicone rubber bonds to unprimed surfaces .. 140
Three epoxy adhesives ... 142
Pipe line welding 144
Cold extruding titanium... 146
Polypropylene resins 148
Silicone additive 148
Beryllium bolts 150
Electrolytic cutting 152
Glass-plastics tubes 152
High strength steel 154
Self-luminous paint 156
Thermal insulation 156
Lined steel pipe 158
New welding torch 158
Epoxy compounds 160
Aluminum alloy 162
Fluorocarbon dispersion .. 162
Resistance welding 164
Packaging material 164
Other news 166



Featured above are two of the new line of high performance Jacobsen power mowers . . . and their durable, functionally styled MARLEX components—(1) grass catcher, (2) grass chute, (3) cowling, (4) wheel hub.

Tough, lightweight parts of MARLEX* Increase sales appeal of Jacobsen reel and rotary mowers

Jacobsen Manufacturing Company of Racine, Wisconsin, chose parts of MARLEX high density plastic to dramatize the superior performance . . . and add increased sales appeal to their new line of high performance power mowers.

On reel mowers, grass catchers thermoformed from MARLEX sheet are lightweight, tough, and more durable. They will never rust, rot, or tear . . . should normally last the life of the mower. On Jacobsen rotary mowers, discharge chutes, wheel hubs and engine cowlings of MARLEX—functionally styled with integral color—offer the same advantages of resistance to abrasion, toughness, freedom from rust, and long life. Engine cowlings of MARLEX have the added advantage of protecting hands from accidental burning.

Jacobsen relies on MARLEX plastics (high density polyethylene and ethylene copolymers) to improve their products without increasing costs. These high quality plastics are rigid, tough, colorful, light . . . unaffected by most acids, alkalies, oils, greases, rust and rot. They also possess high di-electric strength and a wide usable temperature range (–180°F to 250°F). For more information, see your plastic fabricator or contact us directly.

*MARLEX is a trademark for Phillips family of olefin polymers

PHILLIPS CHEMICAL COMPANY
Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

Phillips 66 MARLEX

For more information, turn to Reader Service card, circle No. 326

New Materials, Processes Discussed at Design Conference

The most effective means of using new engineering materials in improved and economical designs was the theme of over half the papers delivered at the recent Design Engineering Conference in Detroit.

Discussions of the properties and characteristics of such diverse materials, as ceramics, plastics, adhesives for metals and high strength steels, were intended to assist engineers in "Designing for Today's Competitive Market," the Conference theme.

▸ In discussing the structure of ceramics Marvin G. Britton, Corning Glass Works, pointed out that the mechanical properties of metals have been catalogued and exploited by means of thoroughly tested design principles, so there is a tendency to attempt to do the same with the brittle ceramics. However, Mr. Britton says, this is futile because "test methods, specimens and design concepts are subject to as yet unpredictable variations which force us to use a statistical approach."

Improvement in such tests as those for tensile and compressive strength, plastic deformation and impact strength are vital to the full use of ceramics' properties. Otherwise designs will be over-engineered.

However, experience gained through the continued use of ceramics "will point the way to solving the mechanical loading difficulties," Britton said.

▸ Another area in which design data are inadequate for present needs is the thermomechanical behavior of plastics. R. L. Thorkildsen and J. V. Schmitz, General Engineering Laboratory, General Electric Co., suggested that designers press for more data of this type. One approach they suggested is greater use of an interdisciplinary approach by materials research teams to obtain basic materials data and correlations useful in predicting the behavior of plastics.

▸ Selection of adhesives for bonding metal and the design of the joint configuration were discussed by H. R. Butzlaff and K. F. Charter, A. O. Smith Corp. They pointed out that aluminum-to-aluminum joints made with either a modified phenolic or an epoxy adhesive have almost as much fatigue resistance as the base metal.

▸ New high strength steels have been developed primarily for aerospace and missile applications.

R. A. Lula, Allegheny Ludlum Steel Corp., pointed out that their development has been accompanied by a valuable increase in

First Award Plaque for M/DE's 1961 Design Awards Competition being presented by editor H. R. Clauser to Robert H. Schmitt for his work with AiResearch Mfg. Co., Div. of The Garrett Corp. Presentation was made at a ceremony during the Design Engineering Conference and Show in Detroit.

The winning design, a high-temperature-resistant a.c. motor, and other winners were described in M/DE, May '61, p 131. Mr. Schmitt is now with North American Aviation, Inc.

"Is that the new Norton catalog?"

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It's dog-eared and marked up because it's in constant use by men who want better materials — high purity refractory materials which will stand up under the most extreme thermal, mechanical, chemical, electrical, and radioactive conditions.

This valuable, well-illustrated reference describes in detail the many Norton refractory materials which are helping to solve widely different product and processing problems. Uses range from aiding chemical reactions to stopping neutrons, handling molten metals, protecting rocket engines — and taming lightning.

Catalog lists physical, chemical and electrical properties of CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, NORBIDE* Boron Carbide, and Fused Zirconia. It's thought-provoking...a real "idea-starter!"

You may well profit from this book in solving your own processing problems. No charge or obligation, of course, write for "Norton Refractory Grain,"

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understanding of brittle failure phenomena, particularly under high stresses.

Successful show

The Design Engineering Show was attended by over 18,000 engineers and scientists. According to Clapp & Poliak, Inc., sponsors of the Show, this figure compares favorably with the attendance of 22,500 at last year's Show held in New York City.

This year's Design Show, held in Cobo Hall, was the first to be held entirely on one floor. Over 400 leading companies exhibited—approximately the same number of companies participated in the 1960 Show.

ASTM Votes on Name Change

If events have transpired as scheduled, members of the American Society for Testing Materials have by this time decided whether to change the name of their society.

The decision was scheduled for June 27 at which time this issue was on the presses. The new name under consideration is: American Society for Testing *and* Materials.

According to ASTM, there has been considerable feeling among the members that the present name does not fully express the scope of the Society's activities as it suggests they are limited to testing materials.

Metal data now on coded cards

In another recent action, ASTM has started a new data publishing program. High temperature strength data for metals and alloys are now being offered to industry on code-punched cards.

The packaged method of data dissemination is designed to meet both the profusion of data and industry's increasing need for it in a readily-selective form, according to the ASTM-ASME Joint Committee on the Effect of Temperature on the Properties of Metals.

Data on the cards include: chemical composition, heat treatment, microstructure, hardness, short-time tensile properties, original creep and rupture data, and creep and rupture strength.

Cards, code book and sorting instructions are obtainable from ASTM, 1916 Race St., Philadelphia 3.

News of Societies

American Iron & Steel Institute has elected the following officers: president—B. F. Fairless; executive vice-president—M. D. Howell; vice-presidents—W. M. Akin & A. B. Homer; vice-president & secretary—G. S. Rose; treasurer—E. O. Sommer, Jr.

American Society of Lubrication Engineers has elected the following officers: president—D. M. Cleaveland, Bendix Corp.; vice-president — L. B. Sargent, Jr., Aluminum Co. of America; re-elected treasurer—W. E. Hoch, Viscosity Oil Co.; re-elected secretary—A. E. Cichelli, Bethlehem Steel Corp.

American Welding Society has elected the following District Directors: Middle-Eastern—C. L. Kreidler, Lehigh Structural Steel Co.; Northwest—W. J. Erichsen, Westinghouse Electric Corp.; East-Central—P. J. Rieppel, Battelle Memorial Inst.

American Zinc Institute has announced the following 1961 officers: president—F. R. Jeffrey, National Zinc Co. Inc.; vice-presidents—J. J. Lennon, American Metal Climax, Inc., C. E. Schwab, Bunker Hill Co., H. L. Young, American Zinc Sales Co.; re-elected treasurer—G. H. LeFevre, U. S. Smelting Refining & Mining Co.; re-elected executive vice-president & secretary—J. L. Kimberley.

Four New Research Projects, Facilities Set Up

Four new projects and facilities concerned with the development of new and/or improved engineering materials and processes have been announced recently:

▸ A laboratory for the experimental spinning of synthetic fibers has been established by Fabric Research Laboratories, Dedham, Mass.

The new facility is capable of both melt and solvent (dry) spinning. It can spin nylon, polypropylene, polyethylene, polyester, polyvinyl alcohol, acetate and acrylic fibers.

FRL is reserving 25% of the laboratory's capacity for its own fundamental studies. The rest is available on a consulting basis to industry.

▸ Development of self-lubricating elastomeric materials is the goal of a 12-month research contract awarded to Quantum, Inc., Wallingford, Conn., by the U. S. Navy Bureau of Ships.

The ultimate aim of the project is the production of dynamic seals for rotating shafts that will function for long periods of time without lubrication.

▸ A 35-ton rolling mill that can be used for either hot or cold rolling metal has been installed at Carnegie Institute of Technology.

The mill, a gift of the Weirton Steel Co., will be used by Carnegie Tech. to develop automatic methods of controlling mills operating at high speeds and to improve metal rolling processes.

▸ A precision welding plant was recently completed by the Parts Div., Sylvania, sub. of General Telephone & Electronics Corp., Warren, Pa. It will be an integral part of a research program to develop new and improved processes and materials for the production of highly precise electronic components such as semiconductor mounts, and vacuum tube elements and leads.

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elevated temperature drawing (150,000 psi tensile)
ALLOY STEEL BARS

e.t.d. 150 Alloy needs no heat treating!

e.t.d. 150 Alloy has 150,000 psi tensile guaranteed! (Rockwell C32 minimum)

e.t.d. 150 Alloy machines better than heat treated alloy steels!

Here are cost-reducing advantages

(1) Heat treating problems, costs (and secondary operations) are eliminated. (2) "e.t.d." 150 machines better than heat treated in-the-bar alloy steels. (3) Tool life and finish are excellent. (4) No quench cracks or distortion from heat treatment. (5) "e.t.d." 150 has exceptional strength and hardness uniformity across the bar. (6) End cost of parts is greatly reduced.

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Coming Meetings

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS, annual meeting. Seattle. July 4-7.

SEMICONDUCTOR CONFERENCE, American Institute of Mining, Metallurgical and Petroleum Engineers. Los Angeles. Aug 30-Sept 1.

AMERICAN CHEMICAL SOCIETY, national meeting. Chicago. Sept 3-8.

ENGINEERING MANAGEMENT CONFERENCE, American Society of Mechanical Engineers and American Institute of Electrical Engineers. New York City. Sept 14-15.

HIGH TEMPERATURE CERAMIC-ON-METAL PROCESSES CONFERENCE, American Ceramic Society. Columbus, Ohio. Sept 20-23.

STEEL FOUNDERS' SOCIETY OF AMERICA, 59th fall meeting. Hot Springs, Ark. Sept 24-26.

AMERICAN WELDING SOCIETY, fall meeting. Dallas. Sept 25-28.

PROCESS INDUSTRIES CONFERENCE, American Society of Mechanical Engineers. Houston, Texas. Oct 4-6.

CONFERENCE ON PLASTICS FOAMS, Society of Plastics Engineers, Inc., Buffalo Section. Niagara Falls, N.Y. Oct 5.

2ND INTERNATIONAL CONGRESS ON VACUUM TECHNOLOGY, American Vacuum Society Inc. Washington, D. C. Oct 16-19.

ABRASIVE GRAIN ASSN., fall meeting. New York City. Oct 23-25.

METALLURGICAL SOCIETY, AIME, fall meeting. Detroit. Oct 23-26.

43RD METAL CONGRESS AND EXPOSITION, American Society for Metals. Detroit. Oct 23-27.

AMERICAN SOCIETY OF TOOL AND MANUFACTURING ENGINEERS, semi-annual engineering conference. Toronto. Oct 26-27.

AMERICAN NUCLEAR SOCIETY, 9th Hot Laboratory and Equipment Conference. Chicago. Nov 6.

STEEL FOUNDERS' SOCIETY OF AMERICA, 16th annual technical & operating conference. Cleveland. Nov 13-15.

7TH ANNUAL CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS, American Institute of Electrical Engineers. Phoenix, Ariz. Nov 13-16.

SYMPOSIUM ON CERAMICS AND COMPOSITES, COATINGS AND SOLID BODIES, Society of Aerospace Material and Process Engineers. Dayton. Nov 14-15.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, winter meeting. New York City. Nov 26-Dec 1.

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Why not phone us—Newark, N. J. HUmboldt 3-7700—regarding your requirements for wire cloth made of an uncommon metal? It will expedite matters and we might be able to help you in your selection.

As background for this kind of work, we can point to more than fifty years of wire cloth making, during which time we have made cloths of practically every metal that can be drawn into weavable wire.

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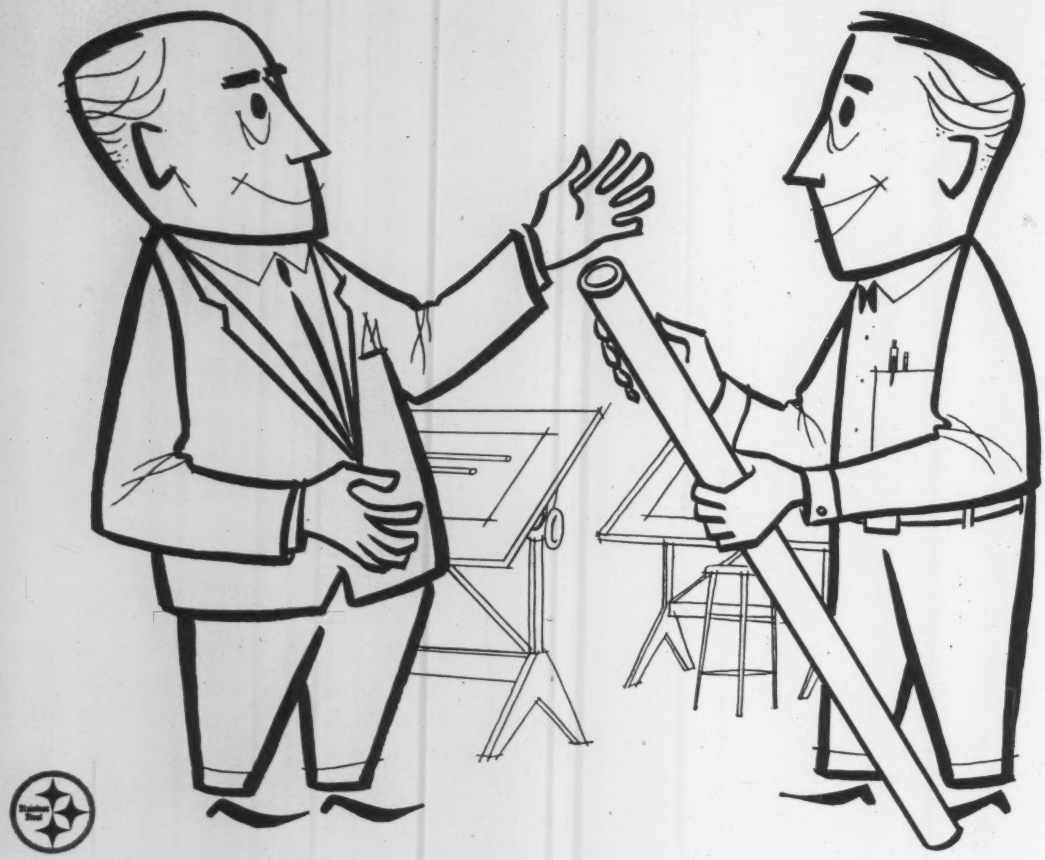

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Use of tubing in human body

To the Editor:

In answer to Dr. Dotter's recent request for information on the use of tubing in the human body (M/DE, May '61, p 29), may I suggest that chemical engineers have analogous problems which are often discussed at annual meetings of the American Institute of Chemical Engineers. These sessions may be of interest because the chemical engineers are not only concerned with the materials of construction, but also the equipment, processes and fundamental concepts involved.

The American Institute of Chemical Engineers has recently made contact with the American Physiological Society with regard to the presentation of programs of mutual interest. Perhaps one or more of the societies that Dr. Dotter represents may be interested in combined sessions which could lead to active cooperation between the two professions.

N. MORASH
(Past National Program Chairman, AIChE)
Development and Engineering Dept.
National Lead Co.
South Amboy, N. J.

Next time we'll be more flexible

To the Editor:

We certainly appreciate the publicity we received from your article "What's New In Foam Plastics" (M/DE, Mar '61, p 119); however, we have received several letters from prospects and customers who felt neglected because they had not been informed about our new "rigid" foam. Actually, our material that you referred to is a flexible urethane foam.

EDGAR O. MACK
Industrial Sales Manager
Scott Paper Co.
Chester, Pa.

Finishing stainless steels

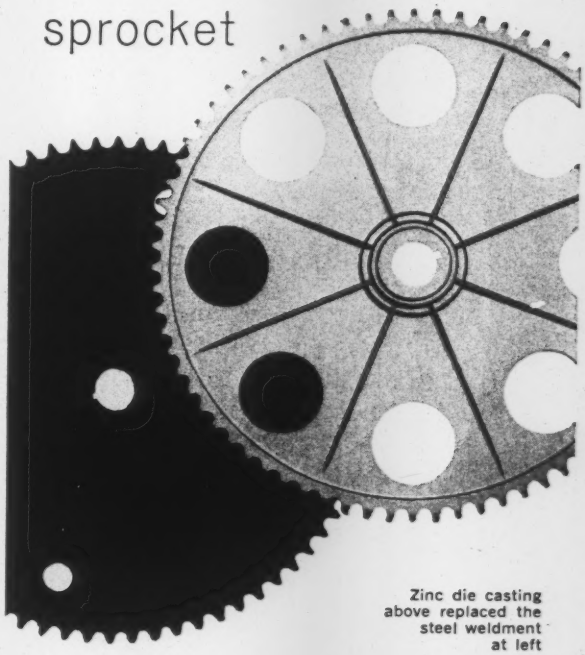
To the Editor:

In your special report on "Chemical Process Equipment" (M/DE, Feb '61, p 111), you made a statement that "a recent study shows that a standard finish such as 2B cleans just as well as polished finishes such as 3, 4, and 7." Is this study available and, if so, how might it be obtained?

DONALD A. HOOVER
Project Engineer
Eli Lilly & Co.
New York, N. Y.

Information has been sent.

ADVANCE put
teeth *
into reducing
the cost of this
sprocket



Zinc die casting above replaced the steel weldment at left

*
By "teeth" we mean Advance engineers bit deep into the cost of the 12-inch steel weldment sprocket shown above and came up with a **saving of better than 50%** in converting it to a zinc alloy die casting.

The sprocket drives the rotating drum of an industrial clothes dryer. Both pitch and O.D. are held to .010 tolerance. Interchangeable cores and inserts readily produce this sprocket with ¾ or 1 inch bore.

Whether it's a conversion, or a die casting of completely new design, putting "teeth" into a die casting cost problem is what Advance engineers like most to do.

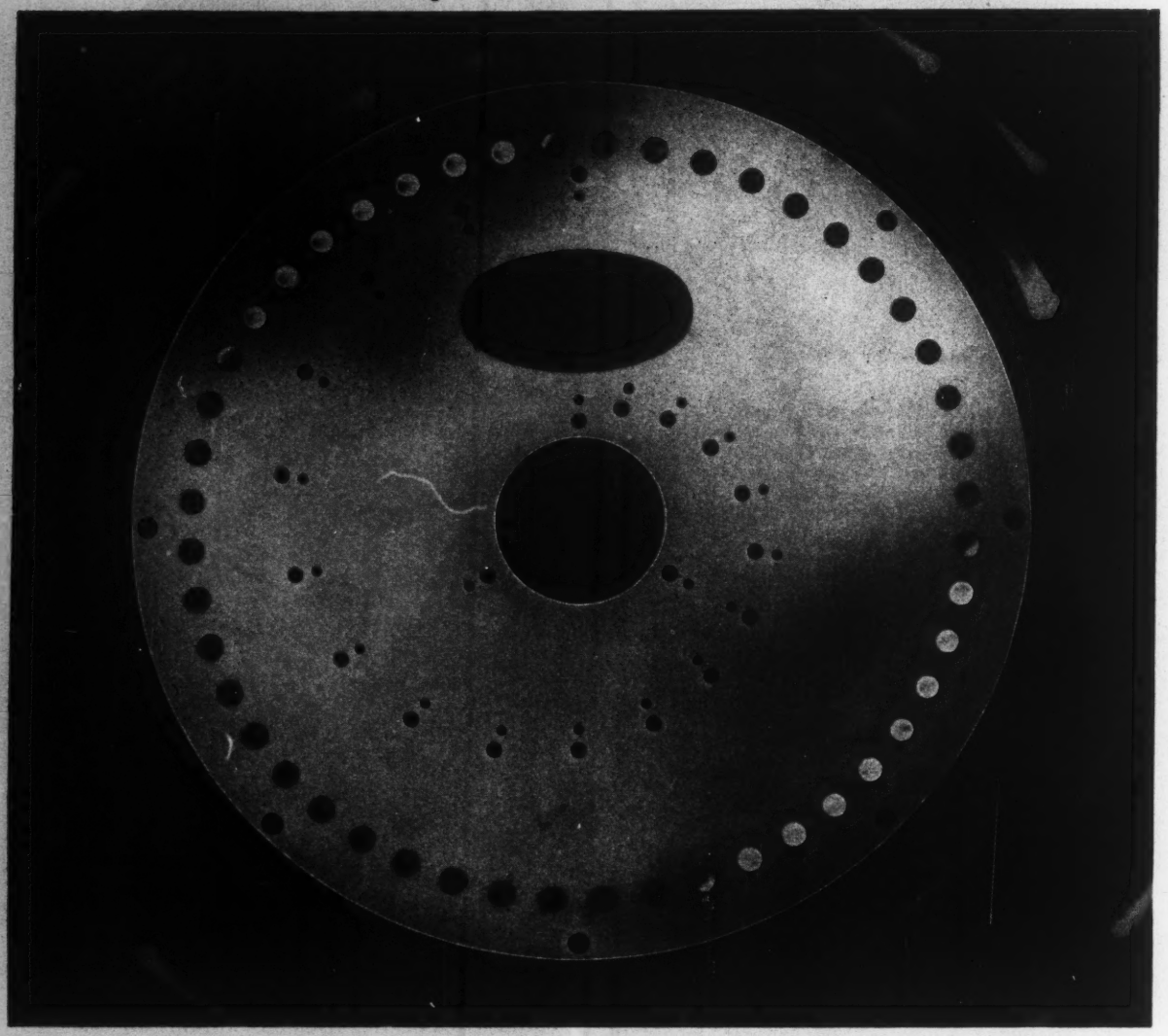
Why not send your next print to Advance for a quotation? Ask for the Advance folder "Your Doorway to Certified Zinc and Aluminum Die Castings".

These symbols are your assurance of highest quality control of zinc and aluminum alloys under ADCI standards.

ADVANCE
TOOL AND DIE CASTING COMPANY
serving industry since 1920
3770 N. HOLTON STREET, MILWAUKEE 12, WISCONSIN

For more information, turn to Reader Service card, circle No. 380

When the requirements seem impossible...



48 precious metal contacts on a 12" circle... maintaining .0003 T.I.R. planar tolerance

To SEE under the sea takes a scanning commutator with seemingly impossible tolerances to insure reliability in ship sonar. That is why compression-molded SUPRAMICA® 500 ceramoplastic machinable insulation was chosen . . . a proud example of MYCALEX CORPORATION OF AMERICA craftsmanship.

The specifications are most demanding, the requirements highly critical . . . plates must be flat within .0003" and embody precision-machined recesses to accept 48 pure silver contacts. The angular displacement of the contacts is held to ±1 minute. The combination of contacts and SUPRAMICA 500 together must accept a 2 micro inch surface finish. The application requires that these tolerances are guaranteed for the life of the commutator during which the environmental conditions run the gamut of humidity and temperature.

The MYCALEX fabricating facility is not only fully qualified to furnish the fabrication of such parts but will design and provide required hardware. For gauge-like specifications on large production runs or short prototype quantities . . . our engineers are ready, capable, and equipped to assist you with your design and production requirements. Write for information on SUPRAMICA ceramoplastics offering maximum temperature endurance (unstressed) up to +1550°F. and SYNTHAMICA® synthetic mica with maximum temperature endurance (unstressed) up to +2000°F. . . . the family of the world's most nearly perfect insulation materials.

General Offices and Plant:
122 Clifton Boulevard
Clifton, N. J.

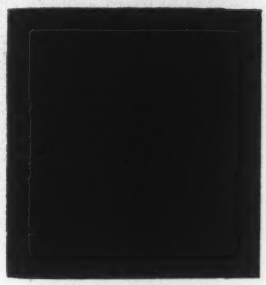
SYNTHAMICA® SUPRAMICA® MYCALEX®

MYCALEX
CORPORATION OF AMERICA

Executive Offices:
30 Rockefeller Plaza
New York 20, N. Y.

World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

For more information, turn to Reader Service card, circle No. 409



Help needed on . . . testing filament structures

To the Editor:

Can you send me any information on testing of glass-epoxy filament wound bottles or structures. I am particularly interested in tests other than hydrostatic and tensile that are possibly being made on the walls of these structures.

RALPH GRUETZMACHER
Research Dept.
Magnaflux Corp.
Chicago, Ill.

Information has been sent.

. . . sources of conductive rubber

To the Editor:

We are interested in finding sources of conductive rubber (or synthetics with the stretching characteristics of rubber). More particularly, we would like to be able to maintain close control over the resistivity factor from batch to batch.

Incidentally, in your editorial in the May issue (p 276), you refer to a theory that if a monkey "were to punch four keys at random over a long period, he would hit upon $E=mc^2$ in less time than it took Einstein." Assuming that the typewriter had an equal sign, it seems to us that he'd have to be hitting five keys.

GERALD SHIRLEY
President
Aldshir Mfg. Co., Inc.
Tuckahoe, N. Y.

Information has been sent on sources for conductive rubber. As far as that monkey is concerned, now that we think of it, he'd have to do a bit more than hit five keys. In addition to finding the shift key to change from lower to upper case letters, he'd have to be quite a clever monkey indeed to manage the exponent.

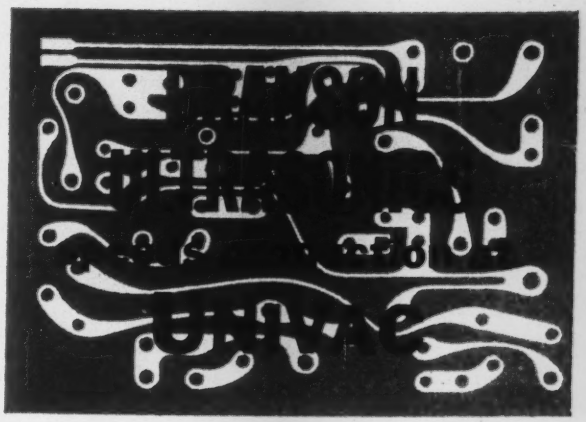
. . . mandrel to form drain hoses

To the Editor:

We are looking for a material that can be used as a mandrel for forming drain hoses during the cure cycle in an autoclave. We want a material that is a natural lubricant with rubber and therefore does not require an artificial lubricant for insertion into the hose and does not require the hose to be heated in hot water to remove the mandrel. A mandrel of the proper material would do two things for us: 1) decrease labor involved in inserting and stripping the mandrel, and 2) reduce housekeeping problems involved in heating the hose and in washing the lubricant from the hose.

W. R. RAEDELS
Senior Methods Engineer
The Maytag Co.
Newton, Ia.

There are several possible solutions to this fairly complex problem. We have supplied what information we could; perhaps our readers can furnish some further help.



The problem: To remove flux from printed circuit boards, formerly done by hand brushing. This method was slow, expensive and not very efficient.

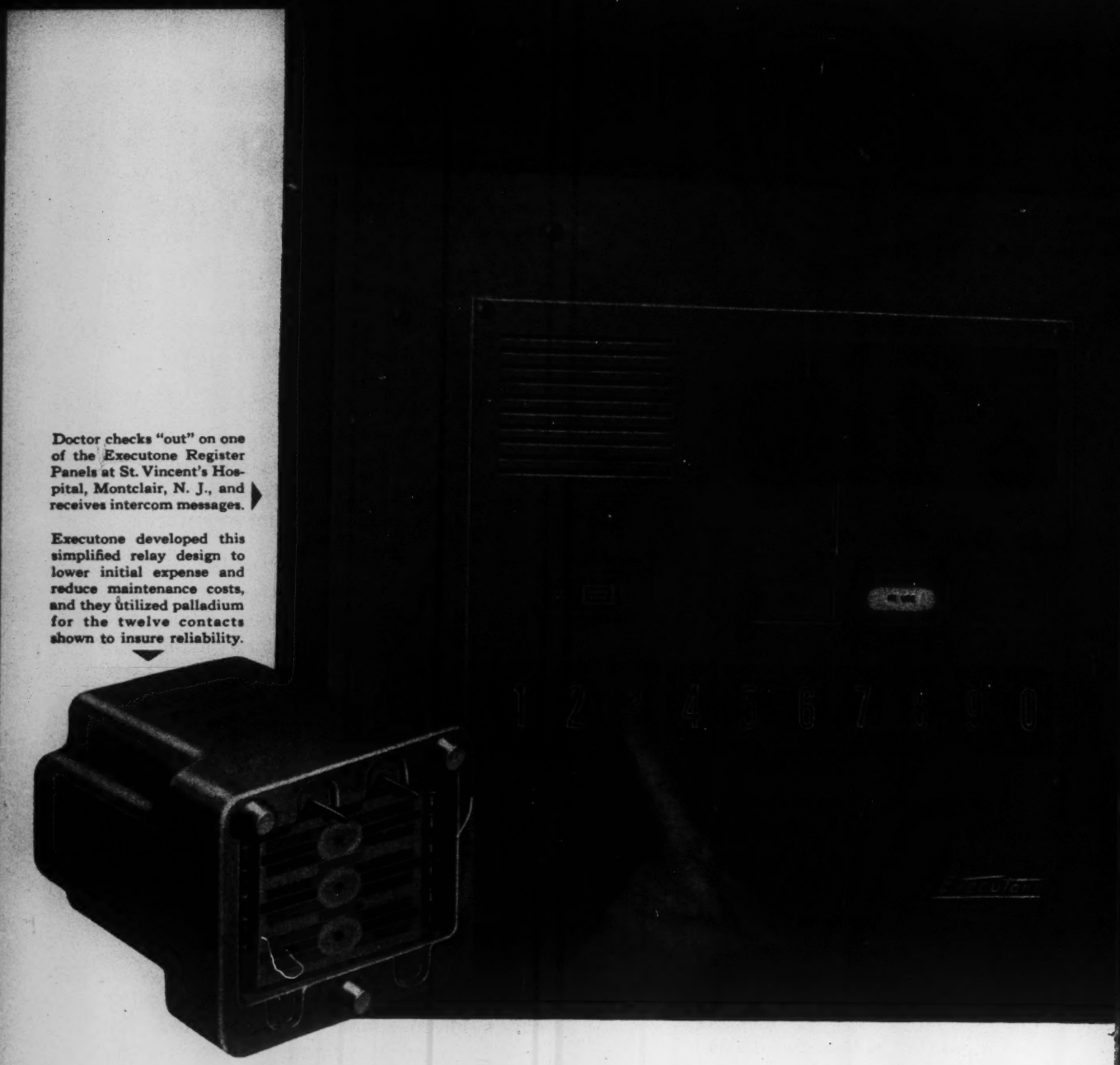
The solution: A "tailor-made" Branson/Univac system that cleans **completely, continuously,** and **automatically.** The ultrasonic installation consists of two 8 foot tanks, each powered by a 1000 watt generator. It is part of a continuous production line, which automatically supplies flux and solder, ultrasonically cleans and rinses, dries and unloads. This process enables Univac to increase production of printed circuit boards considerably. Ultrasonic cleaning assures complete cleanness at high production speed for critical components.

Whether your products are small or large, simple or complicated, you should investigate the use of ultrasonic equipment for your company. Branson's highly experienced, factory-trained specialists stand ready to assist you anywhere in the U. S. Tell us about your particular problem and Branson's engineering department will try to find the **best** possible solution in the **shortest** possible time.

SINCE 1946 — THE RESPECTED NAME IN ULTRASONICS

BRANSON INSTRUMENTS, INC.
Ultrasonic Power Division
17 Brown House Road, Stamford, Conn.

For more information, turn to Reader Service card, circle No. 369



Doctor checks "out" on one of the Executone Register Panels at St. Vincent's Hospital, Montclair, N. J., and receives intercom messages.

Executone developed this simplified relay design to lower initial expense and reduce maintenance costs, and they utilized palladium for the twelve contacts shown to insure reliability.

Where any metal but Palladium

Electronic messenger using palladium contacts improves hospital service and safety.

Keeping track of up to 1000 members of a hospital's staff is the assignment of Executone's Audio-Visual In-Out Register system. At the touch of a few buttons, a doctor can check in or out at an entrance and get his all-important messages by intercom.

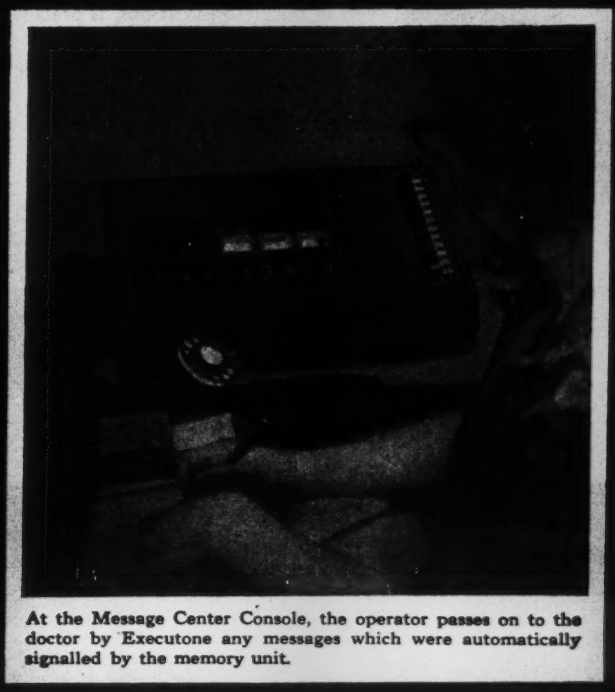
Executone engineers were faced with the task of building the utmost reliability into their system. Its failure *could* endanger lives. Electrical impulses had to be transmitted with absolute accuracy in the memory unit.

They found the answer by using palladium for the all-important contact points of their new Printact* permanent magnet relays on the memory modules. Palladium was the practical choice for handling the intricate switching combinations on the system's rhodium-plated printed circuit boards.

The relay contacts are produced by seam-welding palladium to a nickel base. This material is then rolled to form tape, as supplied by Engelhard Industries, Inc. Tape sections are then used for the 12 Palladium contacts on each relay.

It could pay you to use a Platinum Metal

Your problem might be readily and economically solved with Platinum Metals—where reliable make-and-break electrical contact is indicated, such as in low noise high fidelity transmission ... where wear-resisting, non-tarnishing surfaces are required, such as for printed electrical circuits... where a combination of severe corrosion and erosion must be met, as in the case of spinnerettes for rayon production... where peak catalytic efficiency is required, as in the refining of high octane gasoline... or where product purity must be retained despite high temperatures, as in the case of lens glasses... the Platinum Metals have proved to be the most economical for certain critical equipment.



At the Message Center Console, the operator passes on to the doctor by Executone any messages which were automatically signalled by the memory unit.

would cost too much...

Industry is going to higher temperatures and higher pressures. Perhaps your own progress has been blocked by the limitations of materials to withstand such severe conditions. The Platinum Metals have removed many barriers. Have you considered them for your problems?

Platinum, palladium, rhodium, ruthenium and iridium have unique potentials, well worth your attention. Specialists are prepared to work closely with you in evaluating these metals for new commercial and scientific uses.

As a first step, write us for additional data on the outstanding characteristics and successful applications of the six Platinum Metals and their alloys—indicating your field of interest or how we might be of assistance. *Registered trademark

CAN THESE PROPERTIES OF THE PLATINUM METALS HELP YOU?
Superior Wear Resistance
Exceptional Chemical Inertness
High Temperature Stability
Peak Catalytic Activity
Low Vapor Pressure

The six Platinum Metals are:
PLATINUM · PALLADIUM · RHODIUM
RUTHENIUM · IRIDIUM · OSMIUM

INCO PLATINUM METALS DIVISION, The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

For more information, turn to Reader Service card, circle No. 335

GRAPHITAR®

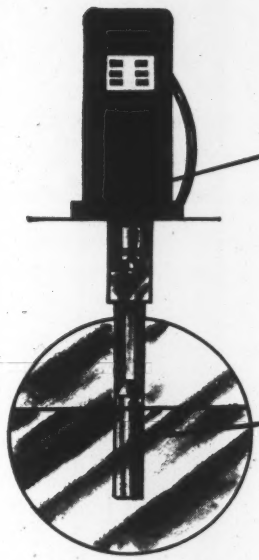
(CARBON-GRAPHITE)

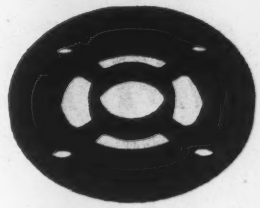
FOR PERFORMANCE

Superior performance and unusually long service life, even in tough applications, is practically second nature to parts made of GRAPHITAR. That's because they combine GRAPHITAR's chemical stability, heat resistance, low coefficient of friction, adaptability to self-lubrication, mechanical strength, hardness and light weight. An everyday application of GRAPHITAR that illustrates well its versatility and remarkable performance can be found in the face-type valves employed in bulk station gasoline meters.

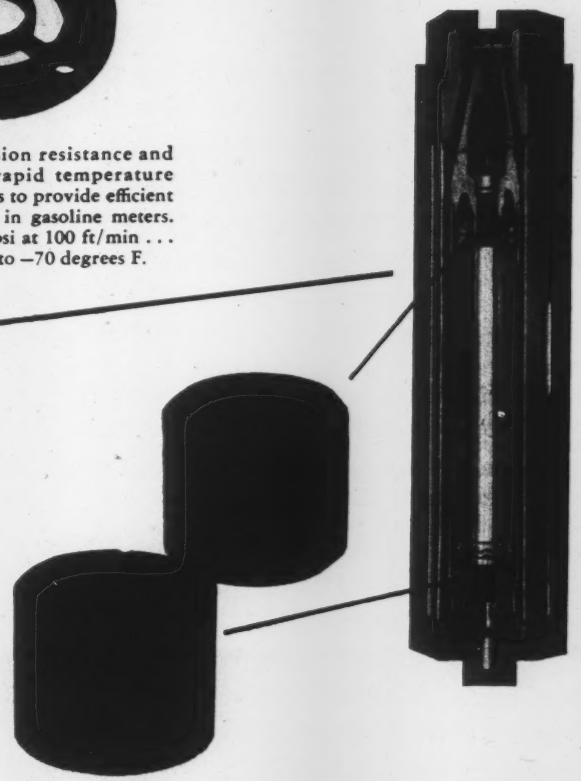
These valves incorporate GRAPHITAR seats. Here, GRAPHITAR's corrosion resistance, chemical inertness and resistance to expansion or contraction under rapid temperature changes, allow the valves to provide a leak-tight seal with excellent wear characteristics. These same characteristics are necessary for good performance wherever steam, gas and chemicals must be handled under the most adverse conditions. Perhaps your product can benefit from the top performance of GRAPHITAR, a unique and versatile engineering material.

Comparative testing of various grades of GRAPHITAR self-aligning seals is accomplished on this equipment, which duplicates actual operating conditions. GRAPHITAR rotary pressure joint seals such as these often operate at 400 psi, at 650°F. and at rotary speeds of 600 ft/min.





GRAPHITAR's corrosion resistance and ability to withstand rapid temperature changes allow valve seats to provide efficient and dependable sealing in gasoline meters. Parts operate under 50 psi at 100 ft/min . . . and from 150 degrees F. to −70 degrees F.



Running directly in the gasoline reservoirs below ground level, a submersible, explosion proof pump depends on two GRAPHITAR bearings to keep its operation safe and smooth. GRAPHITAR is non-metallic, will not weld or score even when in contact with a dry metal shaft. Because GRAPHITAR operates with *any* liquid as a lubricant, it is an ideal bearing material wherever low viscosity liquids such as gasoline are encountered.

Self-aligning seals of GRAPHITAR are employed in rotary pressure joints handling steam, water, hot oil, trichlorethylene, powdered talc and a variety of chemicals. GRAPHITAR has the ability to withstand the action of many such chemicals and only very highly oxidizing reagents in hot and concentrated form can react to destroy GRAPHITAR.

GRAPHITAR is a material uniquely designed by its nature for solving tough problems and improving processing, and it can be further custom-engineered to meet your exact specifications. For complete information on GRAPHITAR send for Engineering Bulletin #[illegible]

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

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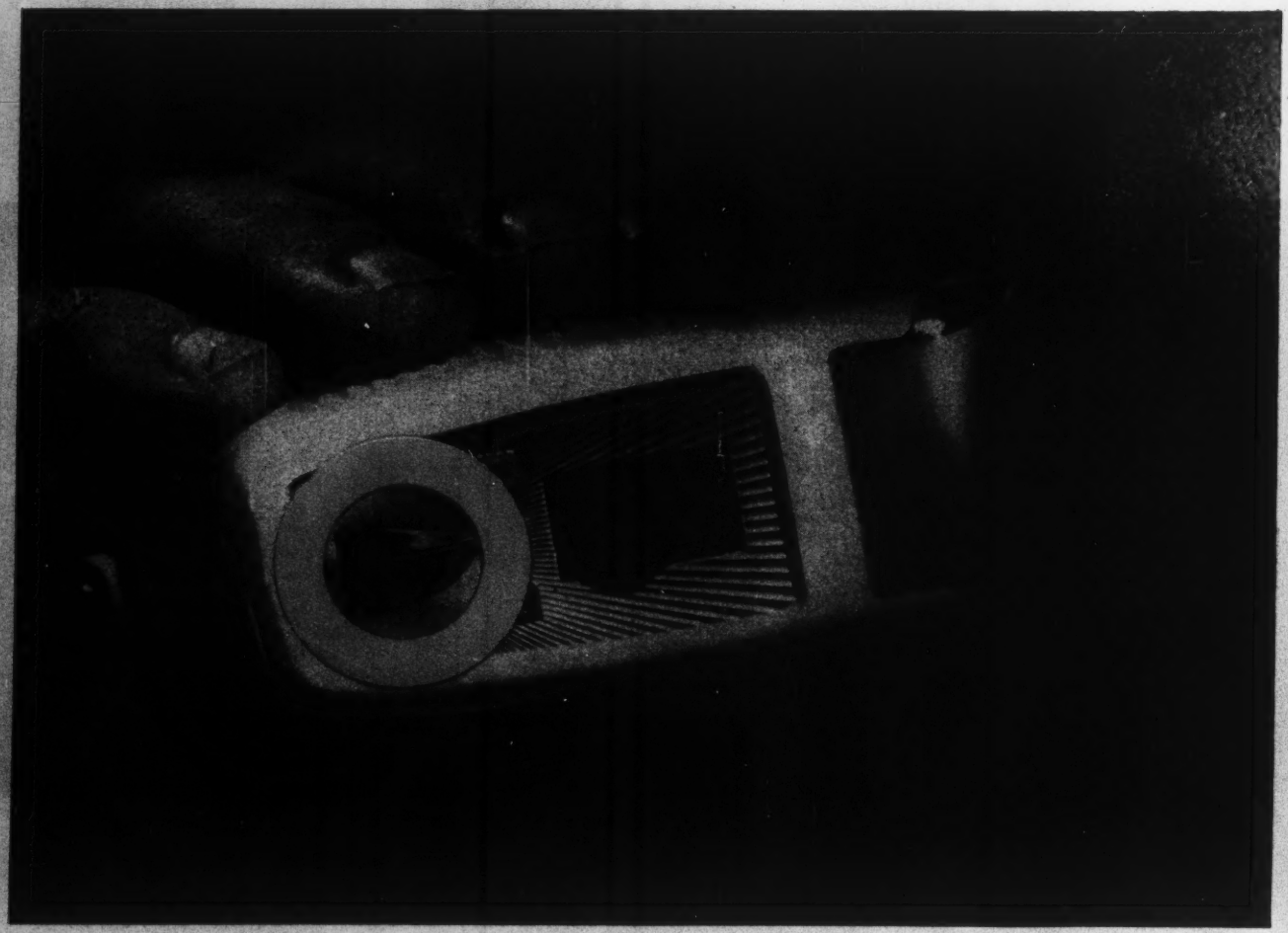
R-299-2

SYLVANIA SHAVES COSTS FOR SCHICK-IN PLASTICS, METALS AND ASSEMBLIES

Producing the switch for a compact, 3-speed electric razor leaves almost no margin for error. It must be precisely built and still withstand the punishing abuse of day-to-day handling.

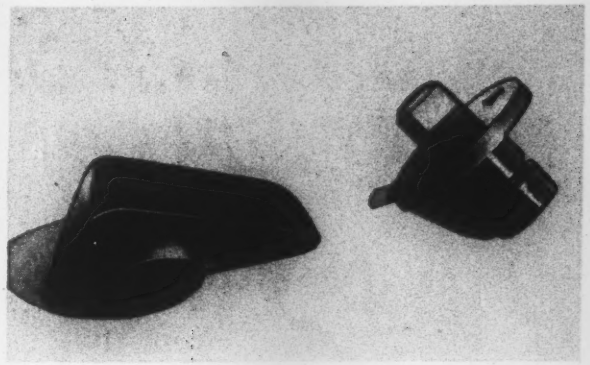
In making the switch for the new Schick razor shown below, Sylvania Parts Division meets these requirements. Our experience with a wide range of materials resulted in better electrical contacts. And our facilities assure durable, precision parts and assemblies as well as high-speed production. The combination means important economies to Schick.

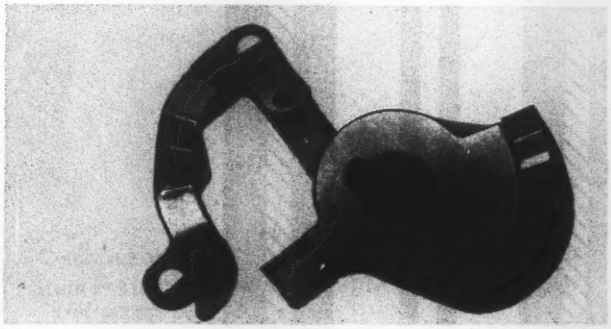
For details, see captions at the right. For full information on how Sylvania custom parts facilities can benefit *you*, or for a quote on a specific project you have in mind, write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.



MOLDED FROM PLASTIC are parts for the switch assembly. Each must meet the tightest specifications. Example: Sylvania molds shaft and selector button from nylon, holds dimensions on both to a height and diameter of ±.0015". In addition, the flash is controlled to 1/32" because the button is a snap fit on the shaft. Since Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment, it can handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to Schick? Precisely molded parts—in volume!



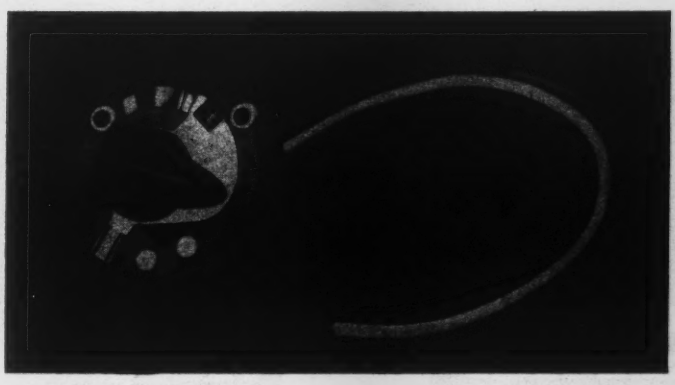


CUSTOM METAL STAMPINGS also proved important to Schick. Sylvania recommended changing the selector detent and rotor to brass, thus permitting a reduction in thickness from .015" to .010" and assuring an improvement in contact from rotor arm to detent. Sylvania made the dies necessary to produce these parts. The Sylvania metal stamping facility includes multi-slide machines, vertical presses and specially developed machines to help solve your problems.

Result to Schick? Positive electrical contacts assured while a 5° offset on the selector rotor is maintained to within ±1° day in and day out.

CUSTOM ASSEMBLY by Sylvania of the switch assembly is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or a combination of some Sylvania and some customer supplied—*at lower cost than is possible in the customer's own facilities.*

Result to Schick? Thousands of completed, durable and precision assemblies per month.



NEED CUSTOM WELDING OR WIRE? Sylvania supplies both. To help you meet your welding needs, Sylvania has developed new high-speed, high-volume techniques and advanced welding equipment—automatic and semiautomatic. To help you with wire, only Sylvania of all major manufacturers makes all three types of bare wire—alloy, clad and plated. They're available in a full range of sizes, too—.002" to .250". Where necessary, Sylvania will precision-roll wire into ribbon connectors that offer high reliability when the circuitry calls for wire wrap contact methods.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

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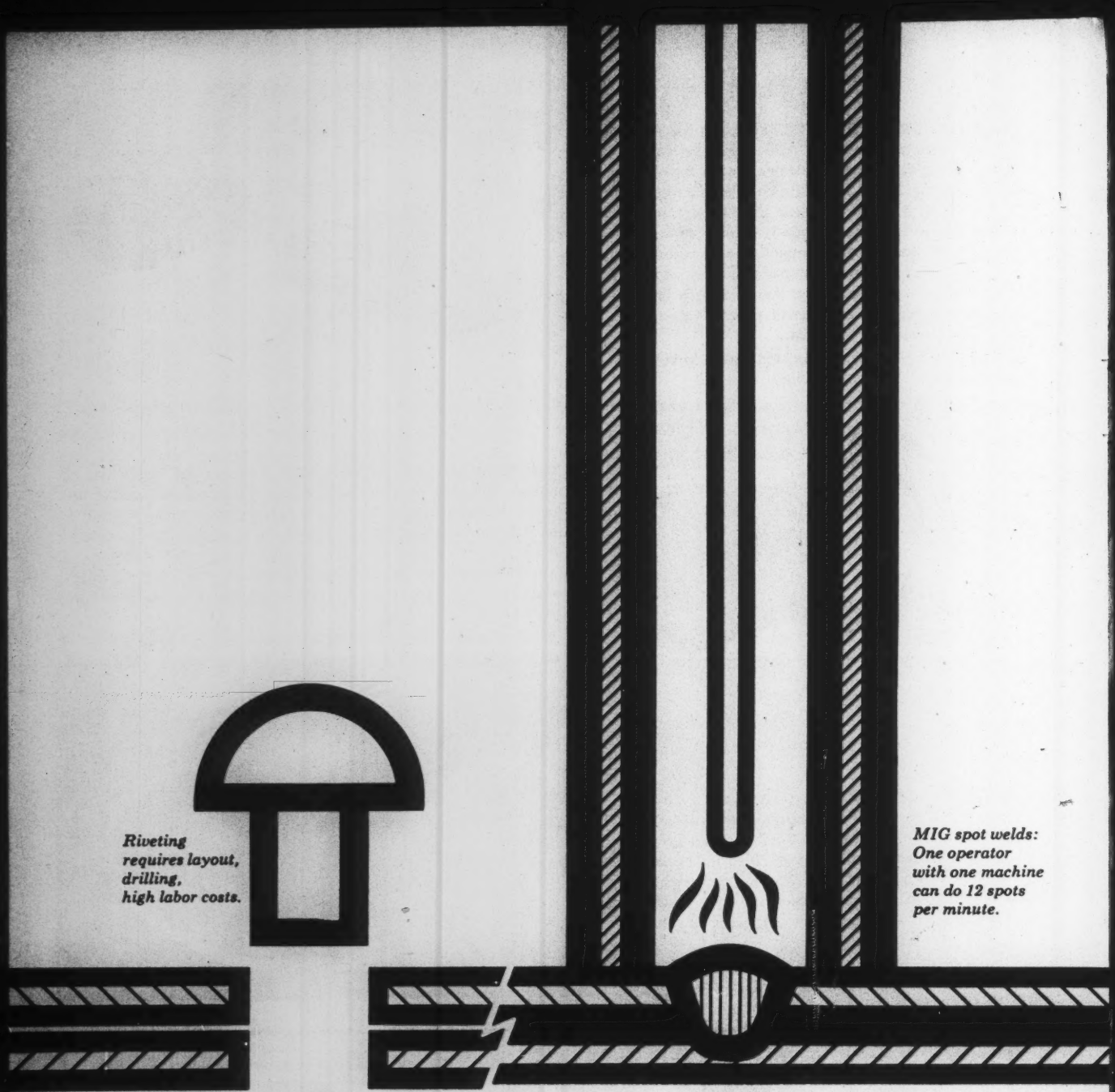


Riveting requires layout, drilling, high labor costs.

MIG spot welds: One operator with one machine can do 12 spots per minute.

6¢ **3¢**

How? Ask Olin:

Olin Aluminum Research has now adapted the MIG welding process for spot welding aluminum; overcoming the old problem of inconsistent results. Where properly designed joints are used, the strength of MIG spot welds is as high as or higher than those of rivets or resistance spot welds, at about half the cost of riveting. No matter what you fabricate — aluminum truck trailers, boats, building products, or the like, Olin Aluminum's technical service may be able to help you adapt their MIG spot welding technique. If you're interested in the higher production rate, decreased labor cost and low equipment investment that makes MIG spot welding 50 to 100 per cent cheaper than riveting, call your local Olin Aluminum Sales Office and our expert metallurgical and technical service will be on the way.

Olin
ALUMINUM
400 PARK AVE., NEW YORK 22, NEW YORK

For more information, turn to Reader Service card, circle No. 355

LOOK----------

it's all one piece!

Opening and closing this one-piece carrying case demonstrates the remarkable "hinge" property of TENITE POLYPROPYLENE

Flexed a million times in one continuous laboratory test, a molded specimen of Tenite Polypropylene—the Eastman plastic with the "built-in hinge"—showed never a crack. That's why this case can have its base, cover, and handle molded as a unit, with obvious savings in design, fabrication, and assembly.

Made for a child's typewriter, the case is well able to take slam-bang treatment that will come its way. The high abrasion resistance demonstrated in this use gives long life to the beauty of many products made from Tenite Polypropylene, and also suggests its use for gears, bearings, and similar hard-working parts.

In addition to being injection molded, Tenite Polypropylene can be extruded into film, sheeting, and monofilaments, and in special formulations is adaptable to blow molding, where its exceptional strength permits thin walls. The film is sparkling clear, heat-sealable, printable, and an effective moisture barrier—important features in packaging. Rigid sheet is readily thermoformed on standard equipment into large-scale sections or skin packaging.

As extruded wire covering, Tenite Polypropylene exhibits excellent electrical and thermal properties. And formulations combining weatherability, low-temperature flexibility, and high tensile strength may be used to produce monofilaments that are ideal for such applications as webbing for outdoor furniture.

With the lightest weight of any solid plastic, Tenite Polypropylene gives the greatest product yield per pound. As for colors, thousands of vibrant hues are available in Tenite Polypropylene—or in color concentrates for mixing with uncolored plastic to produce the desired color when molded or extruded. Eastman experience in coloring plastics extends over 25 years, with additional background in color photography and textile dyes. In applying this plastic to your product ideas, you can call on the aid of Eastman's technical representatives and its extensive laboratory facilities. For information on Tenite Polypropylene or any other plastics in the Tenite family—butyrate, acetate, propionate, or polyethylene—write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Carrying case molded by manufacturer of the "Tom Thumb" typewriter, Western Stamping Company, Jackson, Michigan.

TENITE®

POLYPROPYLENE

an Eastman plastic

For more information, turn to Reader Service card, circle No. 370

ZINC GALVANIZING

Protects Vital Body Parts In FORD MOTOR CO.'s Compact Cars

COMPARATIVE TESTS PROVE GALVANIZED STEEL BEST CORROSION GUARD FOR VULNERABLE PARTS IN UNITIZED CONSTRUCTION

After 2½ years of evaluation tests, FORD MOTOR COMPANY'S Advanced Body Development decided galvanized steel was the best material for protecting unitized bodies against corrosion.

The box type construction of unitized bodies makes corrosion a critical problem because moisture and road salts become trapped in vital underbody parts. Zinc galvanized steel is expected to give these parts 2½ to 3 times longer life than conventional low carbon steel. This would mean that they will be corrosion-free for 10 to 12 years under normal use.

This is the reason why Ford and other auto makers are now using galvanized steel for the basic framing members of the new unitized bodies.

ANOTHER EXAMPLE OF THE VERSATILITY OF CONTINUOUS GALVANIZED STEEL

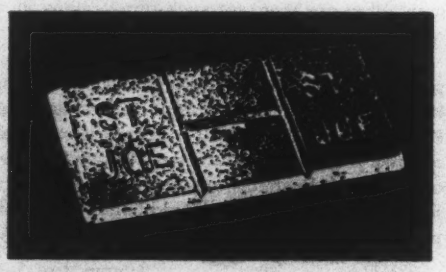
The use shown here is one of a wide variety of applications where continuous galvanized sheet provides the successful combination of protection plus formability. This pre-protected metal can withstand torturous deformation without losing its corrosion-resistance. The zinc coat flows with the base metal — does not chip, flake, powder or peel under severe forming operations.

St. Joseph Lead Co. supplies zinc "electronically-matched" to virtually any specifications which operators of continuous galvanizing lines may require.

ST. JOSEPH LEAD CO.

ST. JOE

250 Park Avenue, New York 17, N. Y.



ZN-166

For more information, turn to Reader Service card, circle No. 385

by vapor diffusion at MISCO

Misco Precision Casting Company has an exclusive license for North America, utilizing the patents, processes, techniques, arts and "know-how" developed by the German diffusion coatings' expert, Dr. Gottfried Becker of "DEW". A vigorous, progressive research program, backed by the facilities of both Misco and DEW, continues the development of new and even better diffusion coatings for both American and European alloys.

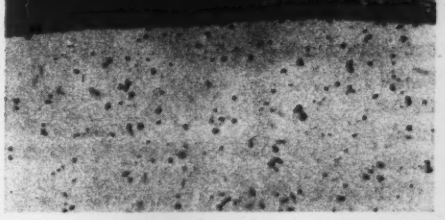
By diffusion coating, certain metals and/or alloys are deposited onto, diffused into, and alloyed with selected base materials to form a protective case, having desired characteristics for the intended service environment, such as—

• high temperature environments.

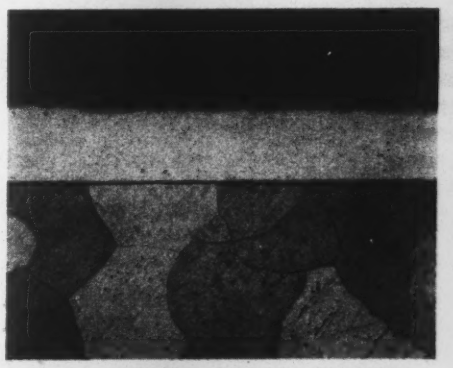
• corrosion resistance. • wear resistance.

Misco Precision Casting Company, widely recognized for the service it provides its customers in the field of precision castings, NOW OFFERS THIS SAME PERSONALIZED SERVICE IN THE FIELD OF DIFFUSION COATINGS.

Our staff can serve you in the solution of your protective metal and alloy coating problems.



Composite coating diffused into nickel base alloy. (100X)



Chromium diffused into low carbon steel. (100X)

Misco Precision Casting Company

DIVISION OF HOWE SOUND COMPANY

MISCO

MONO-SHELL

VECTOR V

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Run through the whole technological gamut of automated machine operations in the plastic industry—compounding, injection and blow molding, extruding, vacuum forming—you name it, a Grace man knows it. This technical assistance is available to all Grace customers as one of the 10 major services in the Grace Service Plan. One more reason it pays to call for that extra touch of Grace.

W. R. GRACE & CO. POLYMER CHEMICALS DIVISION, CLIFTON, N. J.

GREX® POLYETHYLENES · GRACE POLYSTYRENES · MOPLEN® POLYPROPYLENES · ®MONTECATINI TRADEMARK

GRACE
PLASTICS

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New materials in this issue:

	Page	Circle Key No.
METALS		
Alloy steel structurals	9	600
Titanium-clad steel plates	12	602
Zircaloy-2 is vacuum hot pressed	15	604
Tool and die steel	139	610
Electrolytic cutting	152	619
High strength steel	154	621
Aluminum alloy	162	628
PLASTICS & RUBBER		
Fire-retardant foams	10	601
Silicone rubber bonds to unprimed surfaces	140	611
Polypropylene resins	148	616
Glass-plastics tubes	152	620
Epoxy compounds	160	626 & 627
Fluorocarbon dispersion	162	629
Polystyrene foam	164	630
OTHER NONMETALLICS		
Thermal Insulation for cryogenic applications	156	623
Metallized glass is easy to solder	168	637
Fused refractory	168	638
FINISHES, COATINGS		
Ablative coatings	12	603
Vinyl coatings give multicolor effects	139	609
Self-luminous paint	156	622
Vinyl-lined pipe	158	624
JOINING & FASTENING		
Epoxy adhesives	142	613 to 615
Pipe line welding	144	612
Beryllium bolts	150	618
Welding torch	158	625

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2	27	52	77	102	127	152	177	202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677
3	28	53	78	103	128	153	178	203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678
4	29	54	79	104	129	154	179	204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679
5	30	55	80	105	130	155	180	205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680
6	31	56	81	106	131	156	181	206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681
7	32	57	82	107	132	157	182	207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682
8	33	58	83	108	133	158	183	208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683
9	34	59	84	109	134	159	184	209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684
10	35	60	85	110	135	160	185	210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685
11	36	61	86	111	136	161	186	211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686
12	37	62	87	112	137	162	187	212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687
13	38	63	88	113	138	163	188	213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688
14	39	64	89	114	139	164	189	214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689
15	40	65	90	115	140	165	190	215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690
16	41	66	91	116	141	166	191	216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691
17	42	67	92	117	142	167	192	217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692
18	43	68	93	118	143	168	193	218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693
19	44	69	94	119	144	169	194	219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694
20	45	70	95	120	145	170	195	220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695
21	46	71	96	121	146	171	196	221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696
22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697
23	48	73	98	123	148	173	198	223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698
24	49	74	99	124	149	174	199	224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699
25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700

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22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697
23	48	73	98	123	148	173	198	223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698
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Materials for Gaskets, Packings and Seals	682
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Die Castings	680
Adhesive Bonding	679
Guide to Spring Materials	678
Guide to Industrial Textiles	677
Physical Properties and Tests	676
Designing with Metal Powder Parts	675
Organic Coatings for Metal Products	674
Guide to Plastics Selection	673
How to Select a Stainless Steel	672
Sheet Formed Plastics Parts	671
Sleeve Bearing Materials	670
Designing Metal Stampings	669
Paper as an Engineering Material	668
Porcelain Enamels, Ceramic Coatings	667
Designing with Heat Treated Steels	666
New Developments in Ceramics	665
Thermal Insulation Materials	664
Aluminum Alloy Castings	663

Suppliers' Literature
Books, p 45
Reports, p 45

Suppliers' New Bulletins

Failure of Metal Parts. Advance Industries, Inc., Electrolizing Co. Div., 8 pp, illus. Article discusses premature failure of precisely engineered metal wear parts and bearing surfaces as a function of microscopic nonmetallic abrasive contaminants mechanically embedded or electrostatically "bonded" to components during finishing operations (grinding, lapping, honing, and polishing). **1**

Iron Powders. Alan Wood Steel Co., 4 pp, illus., No. 962. Information on services and facilities available for the production of iron powders. **2**

High Strength Steel. Allegheny Ludlum Steel Corp., 24 pp, illus., No. TS-38. Composition, heat treatment, fabrication data, room and elevated temperature properties, typical applications, and other information on structural uses of a high strength steel. **3**

Polyester Resins. American Cyanamid Co., Plastics & Resins Div., 8 pp, Jan '61. Characteristics, advantages, available types, uses, operating procedures, safety, coloring, and other information on polyester resins for spray-up application. **4**

Iron Powders. American Metal Climax, Inc., Pyron Co.-Amco Div., 8 pp, illus. Chemical and physical properties, composition, packaging and delivery information, available grades, and other information on iron and alloy powders. **6**

Metallurgy of Tubing. Babcock & Wilcox Co., Tubular Products Div., 36 pp, illus. Series of short articles give information on such things as high temperature applications of tubing, elevated temperature strength, machinability, nondestructive testing, stress corrosion cracking, effects of alloying elements, residual stresses, heat treatment, hardenability, mechanical properties, etc. **7**

Water-Base Coatings. Bee Chemical Co., 4 pp, illus. Advantages, characteristics, typical uses, and other information on a clear water-based spray and dip coating for protecting plated metal parts. **8**

Laminated Plastics. Continental-Diamond Fibre Corp., Newark, Del., 20 pp, illus., No. D-61. General descriptions, advantages, characteristics, properties, sizes, specifications, and other information on laminated plastics sheet, rod and tube. Includes information on metal-clad grades. Write on company letter directly to Continental Diamond Fibre Corp.

Ceramics for Electronics. Diamonite Products Mfg. Co., 6 pp. Information on services and facilities available for the production of high alumina ceramics specially formulated for use in vacuum tubes and semi-conductor assemblies of all types. Includes information on parts and components for production metallizing. **10**

Resistance Wire. Driver-Harris Co., 2 pp, illus., No. 102. Advantages, characteristics, properties, specifications, and other information on a fine resistance wire for precision resistors and potentiometers. **11**

Synthetic Rubber. E. I. du Pont de Nemours & Co., Elastomers Chemicals Dept., 8 pp, illus., No. 99. Series of case histories illustrate advantages, characteristics and typical applications of neoprene, Viton, urethane, and Hypalon synthetic rubbers. **12**

Stainless Steel. Eastern Stainless Steel Corp., 22 pp, illus. Information on the services and facilities available for the production of stainless steel sheet, plate, strip, and coils. Includes chemical compositions of most common stainless types, and available thicknesses, widths, and lengths of sheet and plate. **13**

Technical Ceramics, Crystals. Electro-Ceramics, Inc., 7 pp, illus. Information on services and facilities available for the production of piezoelectric ceramics and crystals, oxide ceramics, special purpose ceramic bodies, and electroacoustic transducers. Includes typical property values for several alumina ceramics. **14**

Glass-Bonded Mica. Electronic Mechanics, Inc., 4 pp, illus. Advantages, characteristics, electrical and mechanical properties, fabrication data, applications, available sizes and grades, and prices of glass-bonded mica substrates and printed circuits. **15**

Silicones. General Electric Co., Silicone Products Dept., 8 pp, illus., No. CDS-129C. General descriptions, advantages, characteristics, uses, and other information on various silicone products, including fluids, protective coatings, electrical insulation, and silicone rubber. Includes a selector guide for silicone rubber and a grouping of product types under specific end-use categories. **16**

Electrical Contacts. Gibson Electric Co., 4 pp, illus., No. 601. Properties, design information, sizes, typical applications, and other information on a line of electrical contacts. **17**

Prealloyed Powders. Hoeganaes Sponge Iron Corp., 4 pp, illus., No. 128. Advantages, characteristics, properties, and uses of prealloyed stainless steel and high alloy powders. **18**

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Thermal Insulation. Johns-Manville Sales Corp., Industrial Insulation Div., 64 pp, illus., No. IN-244A. Information on commercial and industrial insulation materials for applications ranging from —400 to 3000 F. Includes a description of materials, available forms, typical uses, advantages, physical and mechanical properties, dimensional tolerances, thermal conductivity, temperature limits, and standard sizes and thicknesses. **20**

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Molded Rubber, Plastics. Lee Rubber & Tire Corp., Republic Rubber Div., 4 pp, illus., No. DM-606. Services and facilities available for the production of molded rubber and extruded flexible vinyl parts. **25**

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Powdered Metal Parts. National Sinter-Seal Co., 4 pp, illus. Advantages, characteristics, properties, and other information on a specially compounded thermosetting resin which fills the pores of powdered metal parts to eliminate undesirable porosity. **28**

Sintered Nylon Parts. Halex Corp., Sub. of Polymer Corp., 20 pp, illus., No. NST-1. General description of procedures and characteristics of sintered nylon materials. Covers properties, tolerances, machining, recommended tooling and turning speeds, and typical applications. **29**

Tubing Selection Guide. Joseph T. Ryerson & Son, Inc., 4 pp, illus., No. 12-10. Finishes, analyses, sizes, weldability, heat treatment, machinability, relative costs, and typical uses of carbon and alloy steel tubing for mechanical, structural and hydraulic applications. **30**

Blow Molding. Shoe Form Co., Inc., Dewitt Plastics Div., 4 pp, illus., No. 394. General information on what blow molding is, where it can be used, its advantages and limitations, materials that can be used, relative costs, and some hints on design of blow molded parts. **31**

Expanded Metals. Southern Electric, Inc., Designers Metal Div., 36 pp, illus., No. 61. General information on what expanded metals are and where they are used, including advantages, characteristics, specifications, and dimensions of several different mesh sizes and configurations. Includes information on metals that are expanded, typical uses, and how to specify parts. **32**

Carbon and Graphite. Speer Carbon Co., Carbon Products Div. Properties, characteristics, sizes, typical uses, and other information on several grades of carbon and graphite for high temperature applications. **33**

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Finned Tubing. Superior Tube Co., 2 pp, illus., No. 30. Size ranges, tolerances, applications, materials, tempers, ordering information, and other data on straight and spiral integral finned tubing. **35**

High Temperature Plastics Laminate. Synthane Corp., 1 p, No. TD-2. Advantages, characteristics, and mechanical properties of a new heat resistant plastic laminate recommended for applications requiring exposure to 1000 F for short periods of time, or to 500 F for continuous service. **36**

Titanium for Missiles. Titanium Metals Corp. of America, 14 pp, illus. A summary of the six major application areas for titanium in missile construction, including brief discussions of the four most popular titanium alloys. Series of case studies reveal pertinent advantages, characteristics, and cost data. **37**

Carbon-Graphite Materials. Union Carbide Corp., National Carbon Co. Div., 8 pp, illus., No. S-5425. Descriptions of 18 grades of carbon, graphite, and carbon-graphite materials for bearings, bushings, and seals. Includes advantages, characteristics, and properties for each grade. **38**

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Zirconium. Zirconium Association, 14 pp, illus. Series of graphs give corrosion resistance of zirconium. Includes data on over 100 highly corrosive media in concentrations up to 100% and temperatures up to 400 F. **43**

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Ferrous Alloy Castings. American Manganese Steel Div., American Brake Shoe Co., 8 pp, illus., No. S-57. Properties of alloy steel and iron castings. **45**

Vinyl-Metal Laminate. American Nickeloid Co., 6 pp, illus. Specifications, uses and fabrication of vinyl-metal laminate sheets, strips and cuts. **46**

Alloy Steels. Bethlehem Steel Co., 44 pp, illus., No. 415C. Effects of alloying elements, grain size, heat treatment, quenching media, hardenability, carburizing, flame hardening, normalizing, annealing, cold finishing, and other basic information on alloy steels. **47**

PH Stainless Steel Alloys. Cooper Alloy Corp., 12 pp, illus. Composition ranges, mechanical properties, advantages, characteristics, corrosion rates, typical uses, and other data on four relatively new precipitation hardenable stainless steel alloys. **48**

Steel Tubing Catalogue. Copperweld Steel Co., Ohio Seamless Tube Div., 8 pp, illus., No. CS-60. General information, specifications, tolerances, fabrication data and uses of carbon and alloy steel seamless tubing and carbon steel electric welded steel tubing. **49**

Resistance Alloys. Wilbur B. Driver Co., 8 pp, illus. Compositions, properties, specifications, and other data on a line of fine wire resistance alloys for electronic applications. **50**

Metal Powder Parts. Eaton Mfg. Co., Powdered Metals Div., 8 pp, illus., Vol. 18, No. 2. Article discusses metal powder parts in general, several methods of producing them, equipment and facilities required, heat treatment of iron powder parts, and mechanical properties of various iron powders. **51**

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Stainless Steel. Republic Steel Corp., 40 pp, illus., No. ADV-1124. General information, chemical analyses, typical mechanical properties, and applications of 300 series stainless steels. Also included is information on corrosion resistance, high and low temperature properties, fabrication, joining methods and available forms and finishes. **58**

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Steel Strip. U. S. Steel Corp., American Steel & Wire Div., 48 pp, illus. Physical properties, dimensions, tempers and finishes of cold rolled stainless and carbon steel strip. **62**

Plastic Die Steels. Vanadium-Alloys Steel Co., 8 pp, illus. Information on how to select the proper die steel for a specific mold. Includes a chart listing mold and heat treating properties for several grades of die steels. General advantages and characteristics are given for each steel. **63**

Stainless Steels. Vanadium Corp. of America. Information on the history of stainless steel from original experiments through the first large scale production in the United States to the development of present day stainless steels. **64**

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Fabricating Magnesium. Dow Chemical Co., Dow Metal Products Co. Div., 8 pp, illus., No. 141-201-59. Information on machining (milling, drilling, sawing, etc.), forming (deep drawing, stretch forming, spinning, extruding, etc.), and welding (consumable electrode, spot, seam, etc.), magnesium and its alloys. **76**

Refractory Metals. Fansteel Metallurgical Corp., 2 pp, illus., No. F-1152-1. Chart gives complete properties of tungsten, tantalum, molybdenum and columbium. Included is a temperature conversion chart which covers the range from absolute zero to 6512 F. **77**

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Spherical Powders. Union Carbide Corp., Linde Co. Div., 8 pp, illus., No. 1402. Description of a new process for producing spherical powders of metals and alloys in sizes ranging from 5 to 150 microns. Covered are physical data, powder composition, availability and prices, applications, and other information on copper, aluminum, nickel, stainless steel, tungsten and Nichrome-V spherical powders. **88**

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vantages, characteristics, properties, chemical resistance, and uses of corrosion resistant reinforced plastics linings, coatings, floorings, process equipment, cements, and ventilating equipment. **90**

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ABS Plastics. United States Rubber Co., Naugatuck Chemical Div., 20 pp, illus., No. 70750. Physical, chemical, and mechanical properties; performance charts; and typical applications of injection molded, extruded, and sheet formed ABS plastics. **115**

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Inspecting Galvanized Products. American Hot Dip Galvanizers Assn., 32 pp, illus., No. AZI-40. Manual describes significant factors governing inspection, properties, specification, and purchasing of hot dip zinc coatings. Subjects covered include: thickness and uniformity, coating weight requirements, adherence, embrittlement, warpage and distortion, metallurgical structure of coating, methods of testing, etc. Includes data on product design and a check list of defects, possible causes and recommended action. **134**

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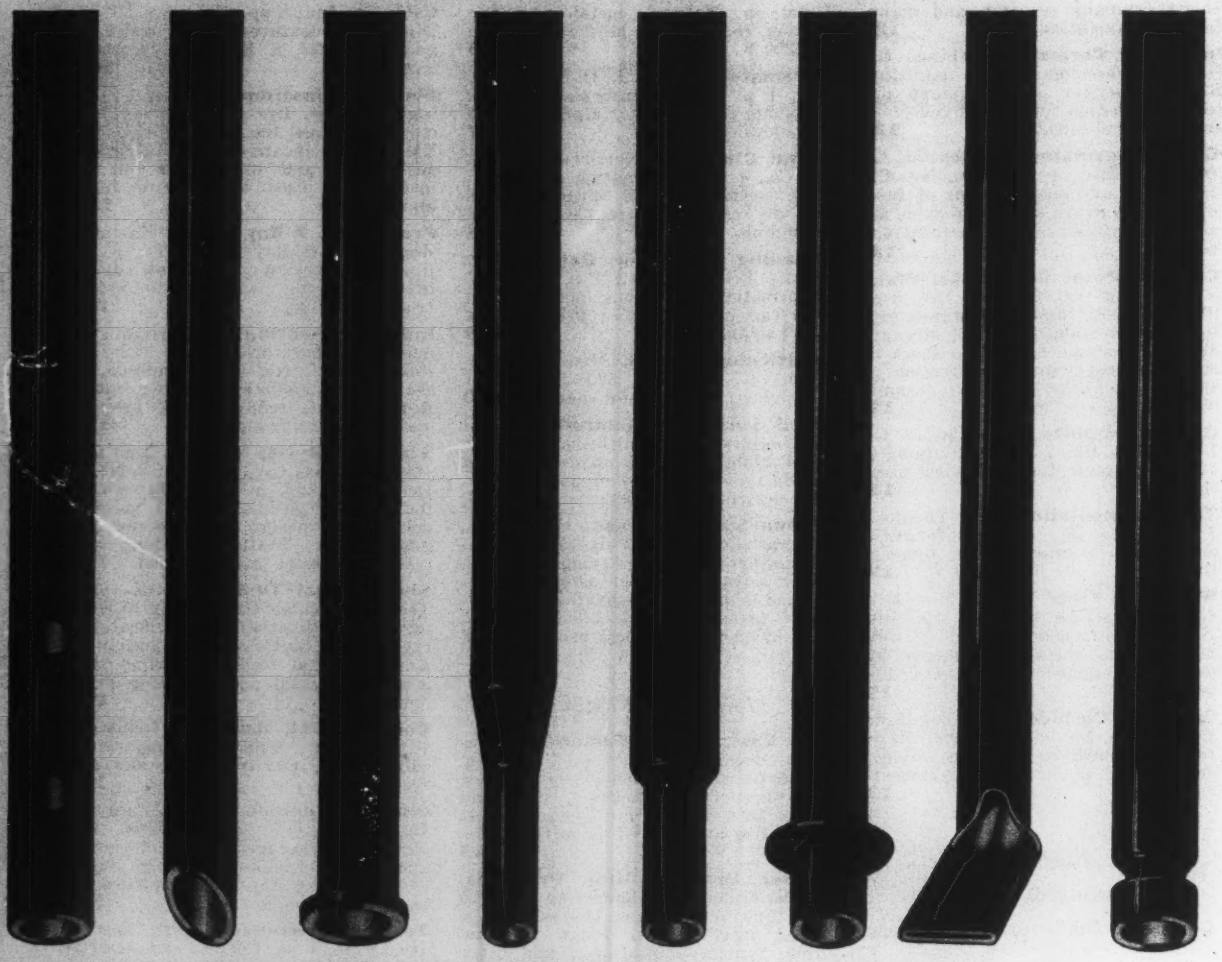

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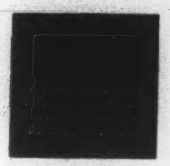

(cont'd from p 43)

Books

Plastics Tooling. *Malcolm W. Riley. Reinhold Publishing Corp., New York. 1961. Cloth, 6 by 9¼ in., 216 pp. Price $7.50*

This book presents a concise, accurate, up-to-date summary of all available information on plastics tooling. It is actually a complete revision of the author's previous volume on this subject.

Many of the materials and techniques described are new, e.g., metal fiber-reinforced epoxies. Some of the materials discussed are still developmental, e.g., gas or electroless nickel-plated surfaces for plastics tools. The author clearly states the degree of use of each technique discussed and includes as much data as possible on those materials which have highly promising futures.

Specific subjects include: why and where to use plastics tools; organizing for plastics tooling; plastics versus other tooling materials; epoxy resins; phenolics and polyesters; flexible mold materials; reinforcements for tooling plastics; fabricating techniques; modification and repair; design; models and prototypes; and future developments.

Modern Materials: Advances in Development and Applications, Vol. 2. *Edited by Henry H. Hausner. Academic Press, Inc., New York. 1960. Cloth, 6¼ by 9¼ in., 413 pp. Price $12.50*

This second volume in the "Modern Materials" series contains seven chapters: polymer-modified papers; modern flame-sprayed ceramic coatings; ceramics for cutting purposes; borides; titanium metallurgy; welding materials and processes; and soldering materials: their production, properties and applications.

Each of the seven chapters, in turn, contains discussions of all or some of the following: fabrication, properties, applications, methods, and recent developments.

Rare Metals Handbook, 2nd Ed. *Edited by Clifford A. Hampel. Reinhold Publishing Corp., New York. 1961. Cloth, 7 by 10¼ in., 715 pp. Price $20*

This revised, expanded, up-to-date handbook presents the full range of currently available data on 55 of the less common metals—from alkaline earth metals to zirconium.

In addition to expanded coverage of metals previously considered, the revised edition includes recently declassified data on such materials as plutonium, cesium, chromium, rubidium, scandium, yttrium, and columbium and tantalum.

For each metal covered the handbook gives: occurrence; production statistics; derivation; manufacture; physical, mechanical, and chemical properties; available alloys; fabrication techniques; typical applications; and future prospects, prices, etc.

Nondestructive Testing. *Warren J. McGonnagle. McGraw-Hill Book Co., Inc., New York. 1961. Cloth, 6 by 9 in., 455 pp. Price $15*

This book covers both the practical methods currently in use and the scientific principles on which they are based. The author's purpose is to explain the "what, why, how, when, and where of nondestructive testing."

Specific subjects include visual testing, pressure and leak testing, liquid penetrant inspection, thermal methods, x-ray radiography, gamma radiography, ultrasonics, dynamic testing, magnetic and electrical methods, eddy current methods and thickness measurements.

Reports

Machining steels TURNING OF HIGH STRENGTH STEELS IN THE HARDNESS RANGE OF 330 TO 560 BRINELL. *Defense Metals Information Center, Battelle Memorial Institute. July '60. 44 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 161208)*

Describes methods of machining hardened steels with carbides, ceramic, and high speed steel tools. Presents guides to the proper selection of feeds, speeds, and depths of cut appropriate to recommended tool materials.

Refractory materials PROPERTIES OF REFRACTORY MATERIALS: COLLECTED DATA AND REFERENCES. *W. G. Bradshaw and C. O. Matthews, Lockheed Aircraft Corp. June '58. 110 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.50 (PB 171 101)*

A comprehensive survey of the properties of refractory materials with melting points above 2500 F. The report contains data on melting points, ductility, thermal shock resistance, thermal conductivity, ther-

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Structural die steels EVALUTION AND ALLOY DEVELOPMENT OF HOT WORK DIE STEELS FOR STRUCTURAL PURPOSES. *M. Schneider and J. Sheehan. Armour Research Foundation, Illinois Institute of Technology. May '60. 94 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 171 008)*

An investigation of the tensile properties of three commercial hot work die steels showed that these materials in sheet form can be heat treated to provide the following properties: 295,000 psi tensile strength, 233,000 psi yield strength (0.2% offset); and 7% elongation (in 2 in.). No significant differences were obtained in longitudinal tensile properties by vacuum or arc melting commercial bar stock.

Titanium property forecaster A MECHANICAL PROPERTY FORECASTER FOR TITANIUM ALLOYS. *C. F. Hickey, Jr., and L. S. Croan. Watertown Arsenal, U. S. Army. Sept '59. 16 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 161 018)*

Discusses an economical, time-saving method of forecasting the mechanical properties of heat treated titanium alloy forgings. The method employs controlled simulated cooling in a thin test coupon section of the material. By duplicating the cooling rates of the heavier section of the material in the test coupon, you can calculate the mechanical properties of the heavier section.

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COOPERATIVE ENGINEERING

The Union Carbide Silicones Man brought these and other requirements back to his team of associates in R&D.

Prior to this, the combined technical and research facilities of Union Carbide Corporation, with tremendous resources of chemical experience and knowledge, had already achieved a long list of "firsts" in silicone rubber, including:

A controlled reactivity, vinyl-containing silicone rubber. A non-volatile catalyst system for one-step curing of thick sections. Electrically conductive silicone rubber. A rubber for electrical tapes, hot-air ducting, and other wrapped constructions. A compound to meet Naval cable specifications for atomic submarines. And the first and only silicone rubber compound qualified for automotive rear pinion seals.

FROM UNION CARBIDE—first commercial silicone compound for high-altitude emergency oxygen masks.

SIERRA ENGINEERING COMPANY of Sierra Madre, Calif., tests every silicone rubber mask it manufactures and maintains an accurate serial number check to be sure the quality is uniform at all times.

MEETING BASIC PRODUCTION PROBLEMS

For Sierra's oxygen masks, the principal properties needed had all been met before, *but not in a single silicone rubber compound.* Working closely with Sierra, engineers of the Silicones Division succeeded in formulating a compound that matched the needs and answered all basic production problems as well.

The new compound permits molding to extremely close tolerances. Its purity means freedom from smoke and fume problems during post-cure. It more than meets Sierra's strict quality controls, including complete performance test records on every mask produced. And the same compound is now also being used for Sierra's oxygen masks designed for military jet pilots and the crews of commercial planes.

MAIL COUPON FOR DATA

If your designing calls for rubber with advantages such as low temperature flexibility, thermal and oxidation stability at very high temperatures, low compression set, weather, ozone, oil resistance, electrical resistance or conductivity, your Silicones Man has them at his finger tips. The coupon below will bring your problems to his immediate attention.

UNION CARBIDE

SILICONES

UNION CARBIDE is a registered trade mark of Union Carbide Corporation.

Silicones Division
Union Carbide Corporation
Dept. GM-9101
270 Park Avenue, New York 17, N. Y.

In Canada: **Union Carbide Canada Ltd., Bakelite Division, Toronto 12.**

Please send me data on _____

_____

NAME _____

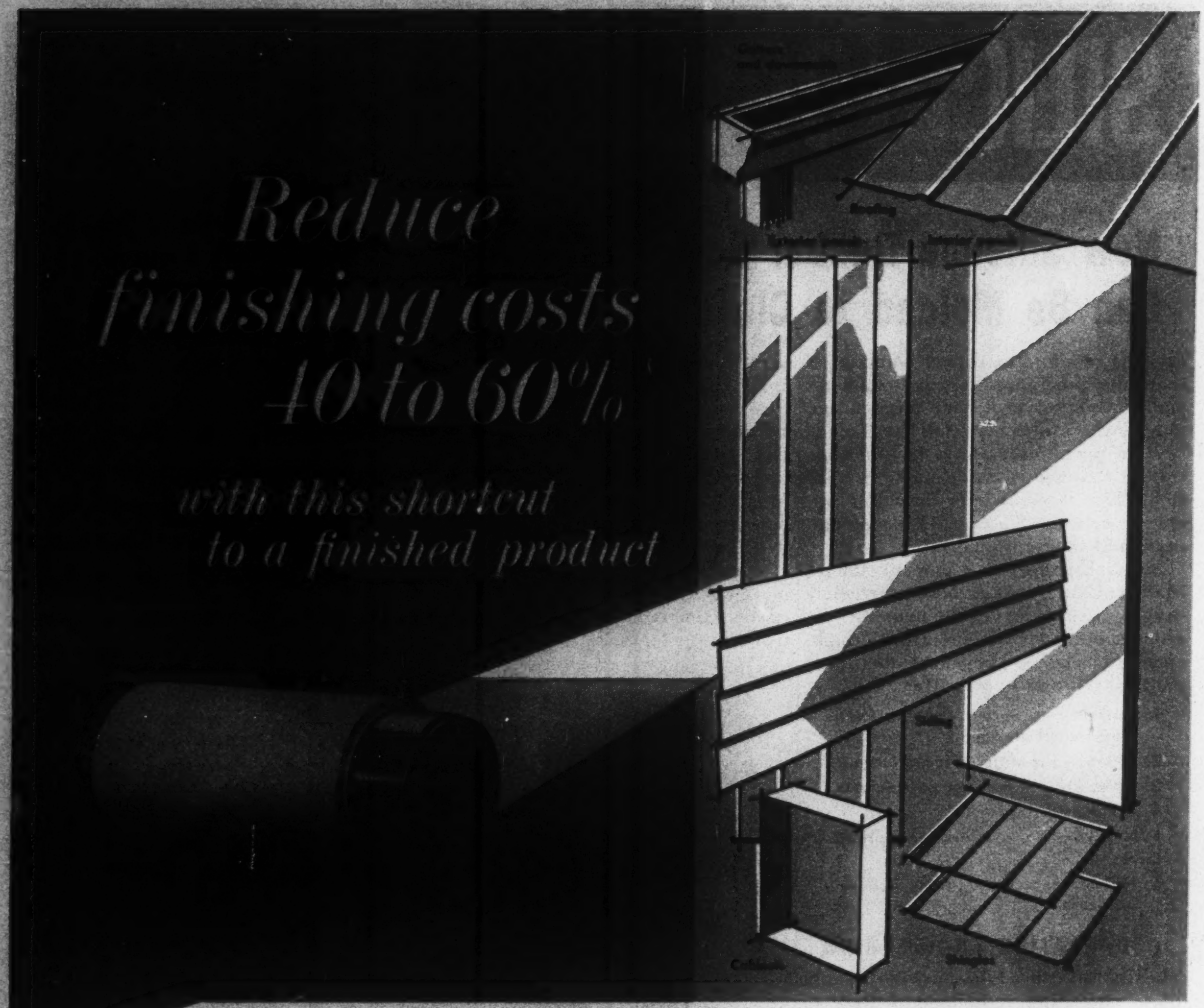
TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ **ZONE** ____ **STATE** _____

For more information, turn to Reader Service card, circle No. 403



FoRM from BONDERIZED painted coil stock

Actual field experience and careful cost projections by manufacturers indicate that finishing costs can be cut 40 to 60% by using pre-painted coil stock. This is true for products formed from steel, aluminum or galvanized, using baked-on, high quality paints over Bonderite.

These spectacular savings result from decreased paint consumption and application costs per thousand square feet of surface..

Manufacturers of many types of products are taking advantage of these savings by using Bonderized, painted coil stock for their production now. Coil stock may be treated and painted in the plant, or purchased already Bonderized and painted, ready for forming and fabrication.

The Parker technical representative near you has full information on this revolutionary new way to reduce finishing costs. Or write to Parker, Detroit.

Bonderite

Parker Rust Proof Company
2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base • BONDERITE and BONDERLUBE aids in cold forming of metals • PARCO COMPOUND rust resistant • PARCO LUBRITE—wear resistant for friction surfaces • TROPICAL—heavy duty maintenance paints since 1883

Since 1914—Leader in the field

*Bonderite, Bonderized, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

For more information, turn to Reader Service card, circle No. 383

How ASARCON Bronze cut to length saves you money

Each time your machinist is left with a costly scrap end from a cast bronze bar, the dollar economy of cut-to-length, continuous-cast Asarcon Bronze is re-emphasized.

When you use 13″ cast bars, you have a remnant problem. For example, a 1″ remnant from such a bar is over 7.6% loss, a 1½″ piece is over 11.5% loss, a 2″ scrap is over 15.3% loss. And the cost of the finished parts *must* include the purchase price of these remnants.

However, you can buy continuous-cast Asarcon Bronze from stock in lengths up to 105″ and cut off short pieces as required, or you can buy cut-to-length pieces to meet each job's specifications. You can eliminate both inventory costs and waste of expensive metal.

In addition to savings on end scrap, Asarcon Bronze bars provide these minimum clean-up allowances: $\frac{1}{32}$″ on diameters up to 4″; $\frac{1}{16}$″ on diameters from 4″ to 5″; $\frac{3}{32}$″ on diameters from 5″ to 9″.

Other important advantages of Asarcon cut-to-length bronze:

- Available from stock in 263 sizes, solids and tubes, from ½″ to 9″ in diameter.
- Superior metallurgical characteristics — no blow-holes, pits, shrinks, hard or soft spots.
- Better physical properties due to higher tensile, yield and impact strengths; greater resistance to metal fatigue.

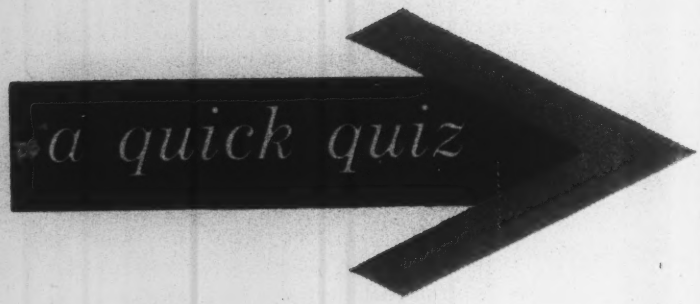
For further information, call or write your Asarcon distributor or write: Continuous-Cast Dept., American Smelting and Refining Company, Perth Amboy, N. J., or Whiting, Ind.

ASARCO

Cutting stock length of 9″ O.D. Asarcon Bronze tubing to exact length specified by customer.

For more information, turn to Reader Service card, circle No. 398

ASARCON® BRONZE



. . . to help you
determine if you
are getting the
most for your metal
finishing dollar.

Check your answers to these three important supplier questions. Then, compare what you get when you buy from Allied Research Products, Inc.

Do I get the results I want at the lowest possible cost?

Always ☐
Sometimes ☐
Seldom ☐

Whether you want quality or economy . . . there's an Allied Research product designed to give you the best finish for the money. Specify your chemicals, equipment, or supplies for better finishing from this list:

IRIDITE®
conversion coatings for non-ferrous metals

IRILAC®
protective coatings for all metals

ISOBRITE®
plating brighteners

ARP®
process chemicals

WAGNER
electroplating equipment

Other standard plating room chemicals and supplies.

Can I get the kind of service I want — where I want it — when I want it?

Always ☐
Sometimes ☐
Seldom ☐

Allied provides a nation wide network of sales engineers and warehouses — service men and laboratories. Prompt product delivery or expert help is as close as your telephone. Check us out on promptness. Call your Allied Research man. Or, write direct if you'd like information on:

Chemicals

Equipment

Supplies

Does my supplier know my industry's finishing requirements?

Always ☐
Sometimes ☐
Seldom ☐

Allied has years of experience helping customers establish quality finishing standards. The performance of many Allied products has helped set quality levels for industry and government specifications in these industries.

Military

Aircraft & Missile

Electrical

Automotive

Appliance

Hardware

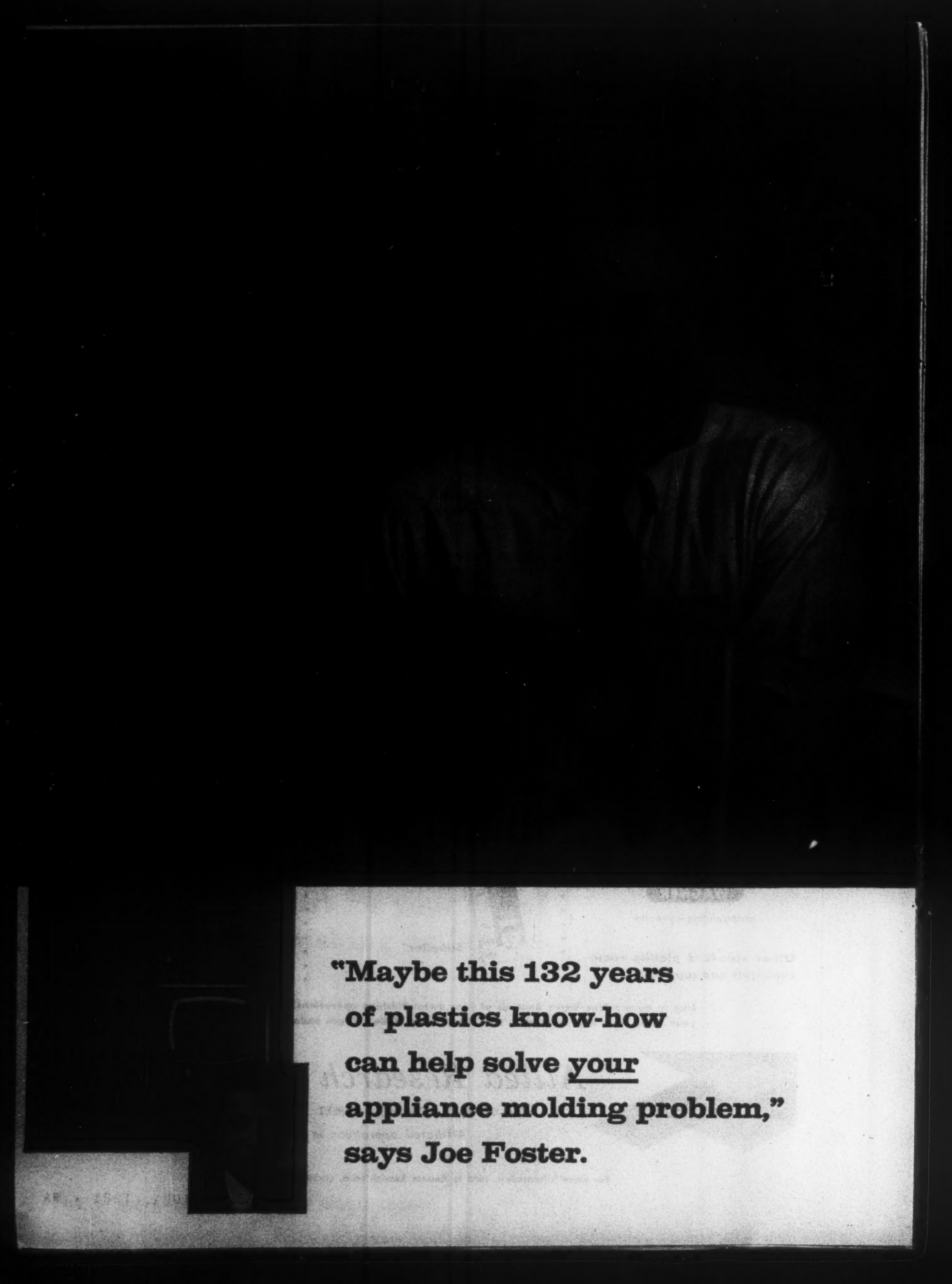
Like to have a free Value Analysis of your metal finishing operations? Write direct or call your Allied Field Representative. He's listed in the Yellow Pages under "Plating Supplies".

Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND

Affiliated operations in principal countries

For more information, turn to Reader Service card, circle No. 418



"Maybe this 132 years of plastics know-how can help solve your appliance molding problem," says Joe Foster.

L. to R.: Jack Iacoboni, Chief of Technical Service; Tommy Eyles, Chief Engineer; John LaBelle, Mgr. of Customer Service and Dr. Ray Hartigan, Dir. of Research, discuss solutions to an appliance manufacturer's molding problem.

That's the total amount of plastics know-how represented by the veteran production-design-research team you see in the above photograph.

These men, who have helped Foster Grant make major contributions to plastics progress over the years, are here solving molding problems in the production of home appliances. Maybe their recent successes with Fosta Tuf-Flex high-impact polystyrene in appliance mold design and production will suggest ways our resins—and our services—may be of value to *you*.

For instance—Fosta Tuf-Flex high-impact polystyrene is being used for refrigerator inner-door liners and freezer doors.

Other current appliance applications for Fosta Tuf-Flex include refrigerator crisper trays and light-bulb shields, intricately die-cast radio cabinets, ice-crusher parts and electric can-opener housings.

Why not put this combined 132 years of practical molding know-how to work on your product design, molding and merchandising problems? Call or write us today. Foster Grant Co., Inc., Leominster, Mass., KEystone 4-6511.

FG

For more information, circle No. 340

Your Partner In Plastics Progress **FOSTER GRANT**

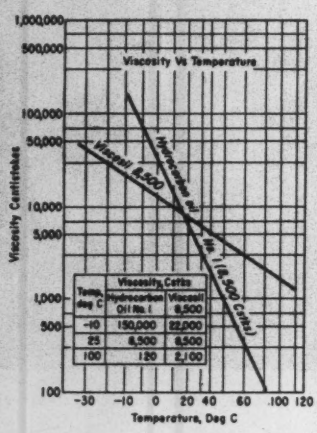
Leominster, Mass.

Fostarene®, Fosta Tuf-Flex® and Fosta® Nylon resins are also distributed by H. Muehlstein & Co., Inc., New York, N.Y.

Speed Monitor, by John E. Mitchell Co., Dallas, uses controlled viscosity of G-E silicone fluids to provide an upper limit to output speed at variable input speeds. It replaces crankshaft pulley to operate fan, generator, compressor and pumps at faster, more efficient speeds in slow city traffic while limiting their speed to optimum level during high speed highway operation. Power is transmitted by G-E fluid sealed between inner and outer rotating members (see cutaway).

GENERAL ELECTRIC SILICONE FLUIDS

for reliable performance under tough operating conditions



Thermal stability. The outstanding thermal and oxidative stability of G-E silicone fluids, over an operating temperature range of —100°F to 600°F, makes them suitable for such rigorous applications as jet engine lubricants and aircraft hydraulic fluids. G-E Versilube fluids give unequalled performance at high temperatures and are comparable to other hydraulic fluids in moderate ranges.

Nearly constant viscosity over wide temperature range. G-E silicone fluids exhibit very small changes in viscosity with wide temperature variations. This makes them ideal for many mechanical applications, including fluid drives, dash pots, vibration dampers, timers, shock absorbers, or wherever constant viscosity is needed.

Get the complete story. These bulletins give complete technical data on the G-E silicone fluid line and describe many of the ways in which designers are taking advantage of their outstanding properties. For your free copies, write to Department B753, General Electric Company, Silicone Products Department, Waterford, N. Y.

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 410

FORMULA FOR FLEXIBLE ANALYSES

LOOKING FOR A SPECIAL COMPOSITION in your steel tubing... perhaps in limited quantities? Then ACIPCO is the ideal source! Here are complete facilities plus the newest process*... ACIPCO CERAM-SPUN®... for producing centrifugally spun tubes to meet the most rigid specifications.

CONSIDER THESE ADVANTAGES: 1. Electric furnaces, both arc and induction type, are available in a variety of capacities... heats can be sized to produce the exact footage required. **2.** With minor modifications for castability, all carbon and low alloy steels can be furnished in compliance with the chemical composition limits of SAE and AISI Standards. Special ferritic chromium-molybdenum alloy steel tubes are manufactured to meet the requirements of ASTM Specification A426-58T. **3.** All ACI corrosion resistant and heat resistant alloys... as well as Cast Monel and ARMCO 17-4 PH.. are available. **4.** Also, gray and alloy cast iron and all grades of AMERICAN DUCTILE IRON® (including the austenitic grades) are regularly cast as pipe, tubes, fittings and specials in all sizes and thicknesses.

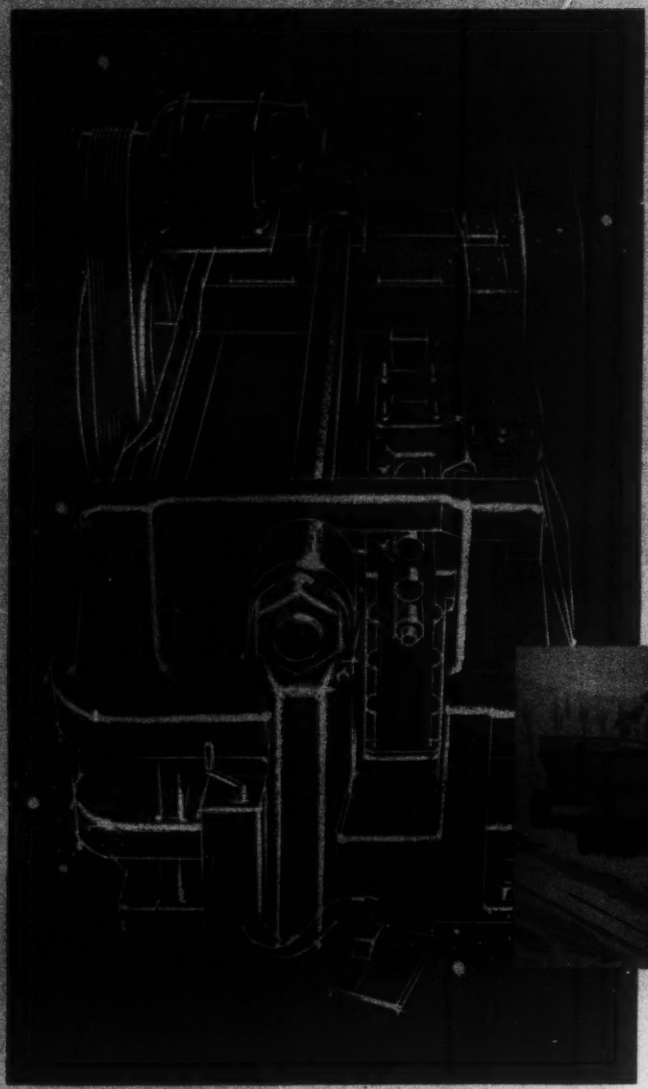
IN ADDITION, ACIPCO offers a wide range of sizes, with O.D.'s from 2.25" to 50". Wall thicknesses vary from .25" to 8"; as-cast lengths from 4 feet to 20 feet; longer lengths can be made by welding.

If you design, manufacture or use parts requiring tubular metal components, it will pay you to investigate the other advantages ACIPCO offers. For complete facts, contact ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

*Patent applied for

ACIPCO CERAM-SPUN®
STEEL TUBING

For more information, circle No. 353



Upsetter, or horizontal forging machine

RESISTANCE TO PUNISHMENT of any severe-service part increased by designing it to be forged

Gear blanks for tractor and farm implement transmissions are designed to be upset-forged, usually with integral forged stub shafts. Forging gives these vital parts maximum resistance to gear-clashing shifts. Transmission life can be equal to equipment life when gears are FORGED.

When you *design with forgings* right from the start, you take full advantage of the many benefits which only forgings offer: highest ratio of strength to weight . . . highest resistance to impact, shock, vibration, torsion . . . preferential orientation of flow lines in the forging to concentrate strength where required . . . absence of wasteful inclusions and voids.

Forged parts start out as *better* metal . . . are made *even better* by the hammer blows or pressures of the forging process. Write for literature to help you design, specify, and procure forged parts.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

For more information, turn to Reader Service card, circle No. 368

AlSiMag

USE: These AlSiMag ceramics have a high volume resistivity at elevated temperatures. Excellent insulators for such applications as metal sheathed thermocouples, heaters, range units, metal sheathed cable, etc.

METHOD: The ceramics are usually supplied in short length, multiple hole, tubing. The thermocouple or heater wires or rods are inserted in the holes in the ceramic and this assembly is inserted in the metal sheath and swaged. Swaging shrinks the tube, crushes the ceramic which thus forms an accurately positioned, densely packed uniform insulation.

MATERIALS: **AlSiMag 689** magnesia, high purity, high Te value. **AlSiMag 714** magnesia, extremely high purity, electrically fused. Particularly desirable for atomic energy applications. Meets purity requirements of AEC Spec. AEC-SR-101 (ORD) and KAPL Spec. O-KPM7-1. (Technical Data Sheets available on request.) **AlSiMag 730**, alumina oxide, extremely high purity.

SHAPES: These AlSiMag crushable ceramics can be made to individual specifications. Multiple hole tubing is most frequently used, normally in lengths of 1" to 4". Dimensional and technical data sheets on request. Send blue print or sketch and performance requirements where special designs are needed.

A Subsidiary of Minnesota Mining and Manufacturing Company

FIBERFRAX® CERAMIC FIBER...

Versatile, high temperature material offers challenging design opportunities

FIBERFRAX alumina-silica fiber insulation is a new class of high temperature material that extends the useful range of fibrous insulations beyond the limits of mineral wools, glass fibers and asbestos. It will not melt below 3200 F and can be used continuously at temperatures up to 2300 F. It has extremely low thermal conductivity, low specific heat, light weight, high thermal shock resistance and chemical stability. This unusual combination of excellent properties offers a challenge to the design engineer seeking new materials for profitable exploitation.

WIDE RANGE OF APPLICATIONS: A typical, highly successful application of FIBERFRAX is in lining the combustion chambers of domestic oil fired furnaces, in which a ⅛" thick FIBERFRAX paper liner replaces brittle, bulky refractories.

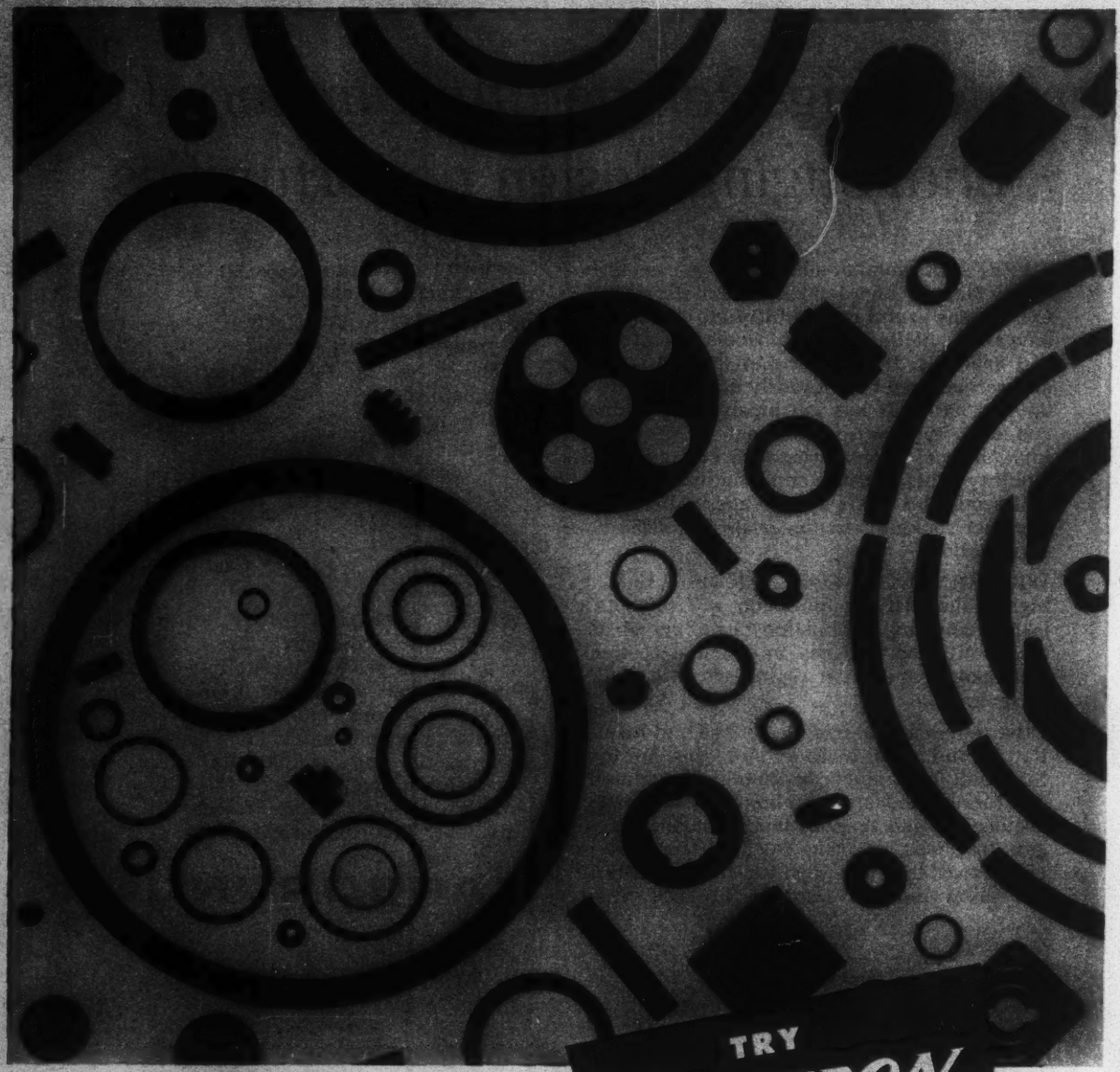
Other applications include linings and insulation for industrial furnaces and kilns, hot tops for metal ingot molds, mechanical cushioning and thermal insulation in honeycomb brazing, accoustical and thermal insulation for jet engine test cells, covering for high temperature electric cable, insulation for roller shafts in annealing and heat-treating furnaces, filters for high temperature gases, and a wide variety of packings and gaskets.

MANY FORMS AVAILABLE: The versatility of FIBERFRAX fiber is enhanced by the many forms in which it is now available. These include,

- Bulk fiber
- Chopped fiber
- Washed fiber
- Long Staple fiber
- Roving
- Yarn
- Rope
- Cloth
- Tape
- Paper
- Board
- Block
- Blankets
- Tubing
- Cast Shapes
- Coating-Cement

WHERE CAN YOU USE FIBERFRAX: The possibilities of the many forms of FIBERFRAX in advanced product design and manufacturing operations are almost limitless. Many are as yet unexplored and offer opportunities for profitable development. *For suggestions that you can use and for complete technical data, write for a comprehensive bulletin to* Dept. MD-91, Ceramic Fiber Project, Refractories Div., The Carborundum Co., Niagara Falls, N. Y.

CARBORUNDUM®



TRY
*PUREBON

HIGH SPEEDS?
HIGH TEMPERATURES?
CHEMICAL CORROSION?

*CARBON-GRAPHITE ESPECIALLY DESIGNED FOR MECHANICAL APPLICATIONS

For bearings, seals, blades and similar sliding or rotating parts, try PUREBON . . . particularly if you have a problem involving high speeds . . . high temperatures . . . or chemical corrosion.

OUTSTANDING PROPERTIES OF PUREBON

1. Self-lubricating
2. Chemically inert
3. Stable at high temperatures
4. Light in weight
5. Readily machinable
6. Moldable to size
7. Low cost, where moldable to size

Request Catalog #60 or see Sweet's Product Design File

PUREBON PURE CARBON CO., INC.

For more information, circle No. 388

For more information, turn to Reader Service card, circle No. 364

Tool Steel Topics

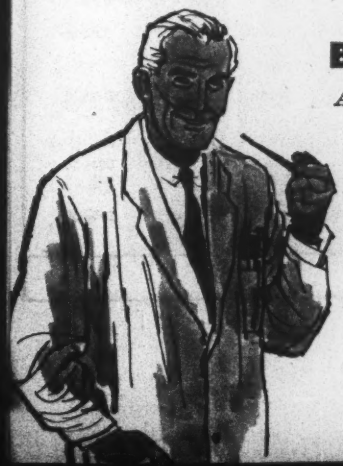
Auto fenders trimmed with dies made from water-hardening tool steel

These photographs, taken at Mardigian Corporation, Warren, Mich., show the use of Bethlehem carbon water-hardening tool steel in trim dies for automobile front fenders. The dies, hardened to Rockwell C 62-64, trim 20-gage cold-rolled sheet steel. In the picture above, 15 sections of the tool steel, bolted into the casting, are ready for "Kellering." The companion picture was taken after the tool steel sections were machined to contour and heat-treated, making a completed form-and-trim die.

Engineers at the Mardigian plant reported fine results with Bethlehem carbon water-hardening tool steel. They especially liked its excellent machinability and uniform response to heat-treatment, plus the fact that modification could be easily accomplished by welding.

Due to their carefully controlled hardenability, Bethlehem carbon water-hardening grades deliver long service in applications calling for high shock-resistance. They have good resistance to wear, and plenty of toughness to resist the effects of cold battering.

Your Bethlehem tool steel distributor has a wide range of carbon water-hardening steels in stock. He will be pleased to meet your needs. Get in touch with him today.



BETHLEHEM TOOL STEEL ENGINEER SAYS:

Avoid Early Failure of Cutting Tools by Removing the "Feather" Edges

When a grinding wheel crosses a tool edge, a small burr or "feather" remains on the edge, no matter how carefully or properly the grinding operation may have been carried out. If the tool is used with the feather-edge, it is equivalent to using a tool having a dulled cutting edge. Obviously, production from such a tool will not be as high as from a similar tool with sharp edges. Many machinists, recognizing this, carry a hand stone which they use in removing the feather from the cutting edges. However, the most practical and positive method of removing the feather from the edges of ground tools is by fiber brushing on a rotary wheel.

By removing the feather-edge before a tool is placed in service, the user is assured of increased production because the edges of the tool do not dull as rapidly.

For more information, turn to Reader Service card, circle No. 378

Monsanto introduces...

LUSTRAN TYPICAL PERFORMANCE DATA

PROPERTIES	Test Conditions	Units										ASTM
Tensile												
Stress at Yield	73° F.	psi										D638-58T
Stress at Failure	73° F.	psi										D638-58T
Elongation at Yield	73° F.	%										D638-58T
Elongation at Failure	73° F.	%										D638-58T
Modulus in Tension	73° F.	psi										D638-58T
Flexural												
Maximum Stress at Yield	73° F.	psi										D790-59T
Maximum Deflection at Yield	73° F.	inches										D790-59T
Modulus in Flexure	73° F.	psi										D790-59T
Impact Strength												
Izod ½" x ½" Bar Mld. (.010" Notch Radius)	73° F.	ft. lbs./in. of notch										D256-56
	0° F.	ft. lbs./in. of notch										D256-56
	−40° F.	ft. lbs./in. of notch										D256-56
Izod ½" x ½" Bar Mld. (.010" Notch Radius)	73° F.	ft. lbs./in. of notch										D256-56
	0° F.	ft. lbs./in. of notch										D256-56
	−40° F.	ft. lbs./in. of notch										D256-56
Hardness												
Rockwell	73° F.											D785-51
Thermal												
Deflection Temp. under Load Unannealed ½" x ½" Bar	264 psi	°F.										D648-56
Physical												
Specific Gravity (Naturals)		—										D792-50

*Data on Extruded Sheet **Monsanto Test +Data on Molded Samples XX½" x 0.115" Bar-Sheet

a new family of plastic materials

LUSTRAN

breaks through the price-performance barrier

LUSTRAN is a high strength plastic material supplied at low cost in performance-tailored formulations. It provides a balanced combination of light weight, unusual toughness and durability, excellent thermal stability and colorability.

With LUSTRAN, you will be able to design the right level of effective strength at the right cost into every product. See for yourself—compare the typical performance characteristics of the LUSTRAN formulations shown against the material requirements of those designs you now have on the boards. You can select a LUSTRAN formulation with *four* times the impact resistance of rubber modified styrene and *ten* times that of general purpose styrene. And, at zero degrees fahrenheit, a ⅛-inch thick 24-inch square sheet withstands the shock of a 6 pound ball dropped 48 inches. LUSTRAN has superior rigidity, excellent surface and gloss appearance, abrasion and chemical resistance and is available in a vast color range.

LUSTRAN—a unique molecular arrangement of styrene and other monomeric materials—has been successfully injection molded into parts weighing as much as 3½ pounds and vacuum formed in deep drawn parts weighing up to 11 pounds. It promises new design possibilities for components and housings for business machines, automobiles, refrigerators, radios and other appliances, packages, luggage and toys. Wherever the performance-cost balance is critical, LUSTRAN can help you. For more data, write to Monsanto Chemical Company, Plastics Division, Department 822, Springfield 2, Massachusetts.

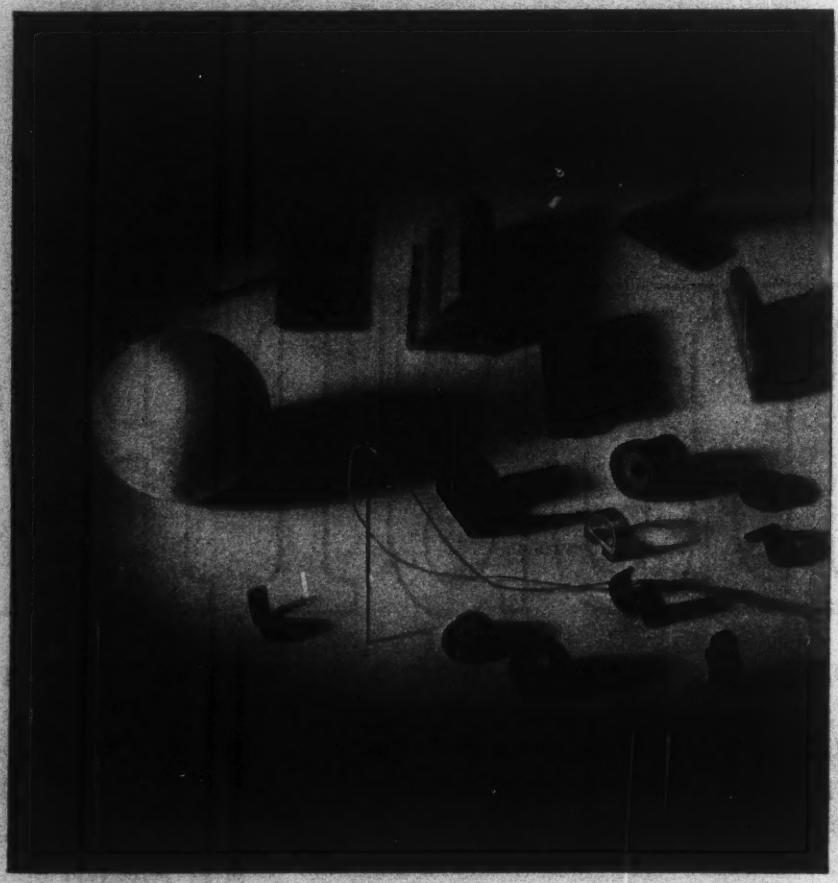
LUSTRAN: Reg. U.S. Pat. Off.

Monsanto

MONSANTO INNOVATOR IN **PLASTICS**

For more information, turn to Reader Service card, circle No. 406

Years of processing rubber parts enable Garlock to practically "thread the needle" with accuracy to meet your size and tolerance requirements.



When you need intricate

MOLDED AND EXTRUDED RUBBER PARTS

. . . depend on Garlock to meet your requirements with utmost precision. No design is too complex, no size too small, no tolerance too exact for the unmatched combination of Garlock experience, skill and production equipment. The minute your specifications are received, Garlock "know-how" goes to work . . . selecting and compounding the right combination of basic materials . . . making the die or mold to exact tolerances . . . insuring the excellence of the finished part through twenty exacting tests and controlled quality during development and production.

Choose from a wide variety of rubbers, each carefully chosen and processed to meet your exacting needs. SBR for general use . . . Natural Rubber for high tensile strength . . . Neoprene for oil and abrasion resistance . . . Silicone Rubber for high and low temperature service . . . Viton* Rubber for extreme temperature and solvent resistance . . . Nitrile and Butyl compounds where their special qualities are required. Your Garlock representative is fully qualified to assist you in selecting the proper material. Call him at the nearest of the 26 Garlock sales offices and warehouses. Or, write for Catalog AD-167, Garlock Inc., Palmyra, N. Y.

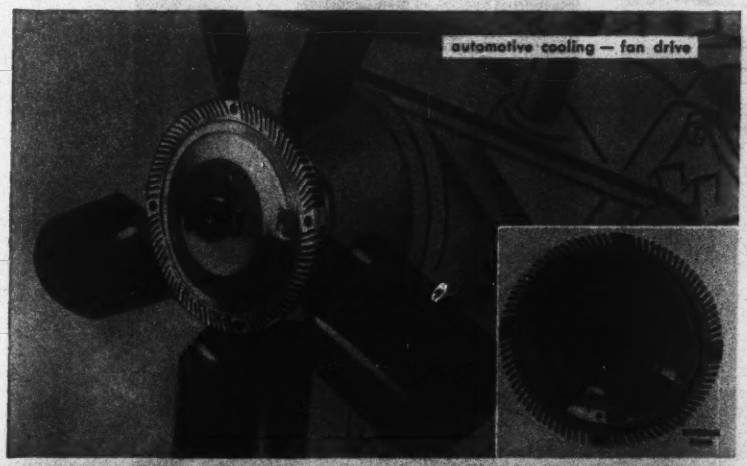
Canadian Div.: Garlock of Canada Ltd. **Plastics Div.:** United States Gasket Company. **Order from the complete line** of quality Garlock products ... Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Stock and Parts. *DuPont Trademark

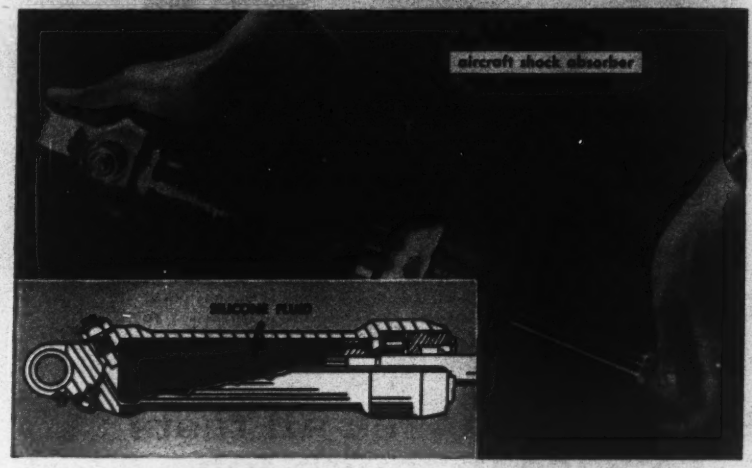
GARLOCK

For more information, turn to Reader Service card, circle No. 362

SILICONE NEWS from Dow Corning

How To Improve Designs





Silicone fluids let you forget time -- temperature

Design more efficient mechano-fluid devices. Assure reliable, uniform performance. Do both with Dow Corning silicone fluids.

Silicone fluids let you forget time because they are resistant to oxidation . . . are nongumming and nonsludging. Silicone fluids let you forget temperature because they maintain a near-constant viscosity, regardless of whether operating environment be hot or cold . . . are serviceable at temperatures as low as minus 100 F; at temperatures as high as 400 F. Furthermore, silicone fluids are highly resistant to breakdown due to shear; are noncorrosive.

These are the reasons silicone fluids make possible design changes impractical with other fluids . . . help improve damping devices, fluid couplings, liquid springs and hydraulic power drives. Here are two typical examples:

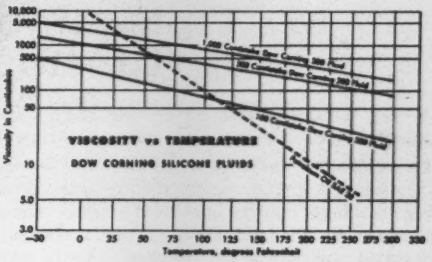
Unimpaired Drive Action

The Visco-Drive assembly shown opposite, designed and manufactured by Eaton Manufacturing Company, automatically slows automotive engine fans at high speeds when cooling is least needed . . . conserves horsepower and reduces noise.

Eaton engineers specify Dow Corning silicone fluid as the drive medium to assure uniform driving action over long periods of time under widely differing conditions.

Soaks Up Shock

Another example is an aircraft shock absorber manufactured by Cleveland Pneumatic Tool Company. Because the Dow Corning silicone fluid used in this liquid spring is much more compressible than other liquids, designers were able to reduce size of the oil chamber by 30%, thus saving vital weight and space.



Learn how other designers are putting to advantage the unusual combination of properties available only in silicone fluids. Send today for descriptive brochure. Address Dept. 7419a.

Your best source for technical assistance in adapting silicones to your products is the Dow Corning office nearest you.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

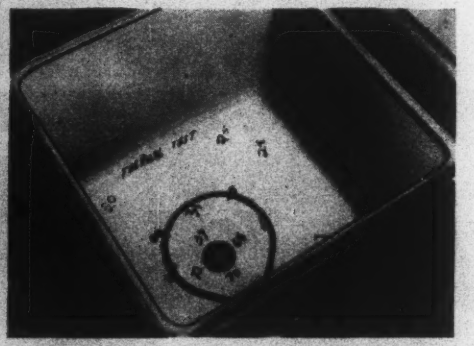
ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

For more information, turn to Reader Service card, circle No. 344

1 Production dishwashers get life tests by being cycled 24 hours a day for the equivalent of up to 15 years' normal use.

2 "Guillotine" test checks resistance of the plastisol lining to cutting. Sample panels can be tilted to various angles found in the tub.

3 Film adhesion of the vinyl to metal is measured on torque scale. Strip of coating is cut where unprimed, wrapped around shaft, and lever turned until primed area is reached.



4 Thermal degradation test used oversize Calrod® heater to assess ability of various thicknesses and formulations of plastisol to maintain color and physical properties intact.

M&T plastisol coating passes all tests for "lifetime" service in tough job

Among the severe applications for which vinyl plastisols are suited, one of the toughest is that of a dishwasher lining.

EXACTING SPECIFICATIONS: Consider the service conditions: scalding water, charged with strong detergents, impinging with high velocity against the lining. The lining has to be immune to all food stains. There's always the chance of dropped objects and broken glass — so the lining has to resist cutting injuries despite the tenderizing effect of heat. Vitally important, such a lining must be non aging. All told, to be completely satisfactory to the materials engineer, it must last the normal life of the machines.

PROVING PRIOR TO APPROVING: Torture tests checked every important physical and chemical property of the sprayed-on lining. Examples:

A unique "guillotine" tested the resistance to cutting. In production tubs, a shower of broken china and glass punished the lining under extreme conditions.

A vapor test gauged the vinyl-to-metal bond in a cabinet at 200°F and 100% relative humidity. If anything should cause loss of bond, blistering or breakdown, this should do it. It didn't. Film adhesion test, food stain and discoloration test, thermal degradation test — these too were applied. On top of all, production dishwashers were cycled 'round the clock for the equivalent of up to 15 years' use.

The Unichrome Plastisol from M & T satisfied all the conditions, and more. It helped insulate acoustically. It helped cut manufacturing costs.

When you require a heavy duty coating, it pays to investigate a Unichrome Plastisol. Various formulations are available to fit specific needs. Coatings provide chemical inertness of the vinyls, film build-up thick or thin as desired, resiliency, and ability to withstand abusive, abrasive service conditions. Send for more data, or for recommendations for your problem.

M&T coatings and finishes

METAL & THERMIT CORPORATION GENERAL OFFICES: RAHWAY, NEW JERSEY IN CANADA: M&T PRODUCTS OF CANADA LTD., REXDALE, ONT.

For more information, turn to Reader Service card, circle No. 331

ALMOST ANYTHING CAN BE IMPROVED... IN PLASTICS MOLDED BY GENERAL AMERICAN

John T. Riddell Inc. wanted safer one-piece helmets for pro football. General American helped provide the answer.

Now every player on every professional football team can enjoy a new measure of protection against injuries. General American worked with the John T. Riddell Co., engineered a "collapsible" mold which made possible the production of one-piece plastic helmets to rigid specifications. These helmets have been proved in gruelling play (and even more gruelling laboratory tests.) The man at the bottom of a pile-up or at the business end of a cleat is safer than ever before.

Resourceful solutions like this are not at all exceptional at General American's Plastics Division. Our engineers and plastics specialists are backed by the largest, most varied molding facilities in the world: compression presses to 2000 tons . . . injection presses to 300 ounces . . . large extruding and vacuum-forming machines unmatched anywhere.

If you'd like to move profitably into plastics, you'll certainly find it pays to plan with General American.

Plastics Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

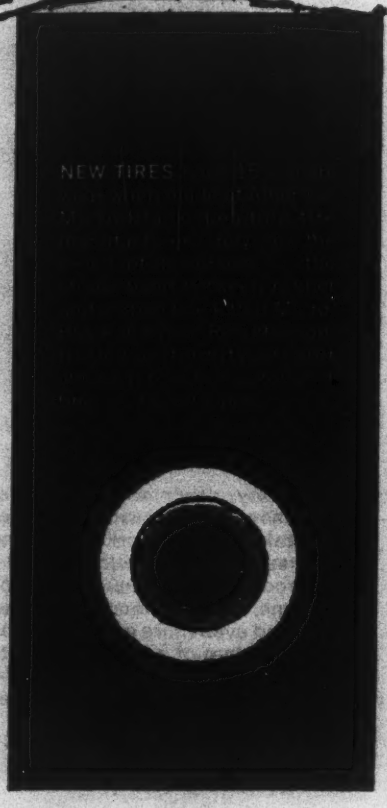
135 South La Salle Street • Chicago 3, Illinois • Offices in principal cities

For more information, turn to Reader Service card, circle No. 395

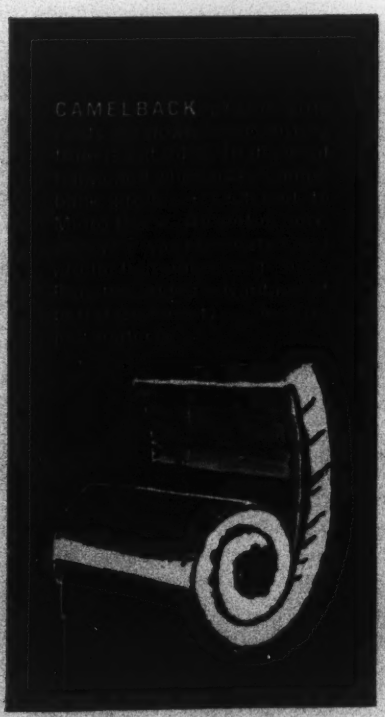
HOLD COSTS DOWN

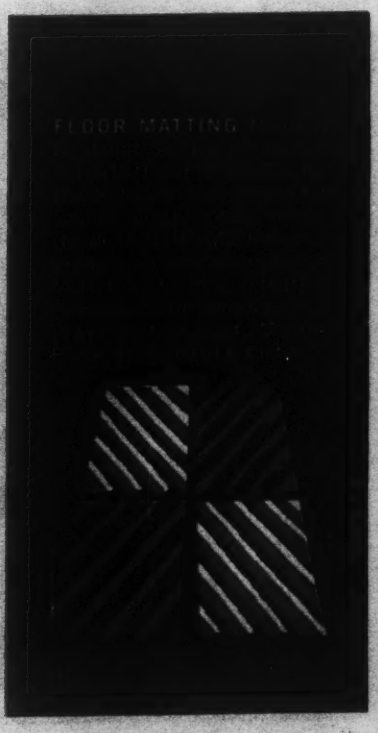
...WITH GOODRICH-GULF MICRO-BLACK MASTERBATCH

■ More and more of today's progressive processors and fabricators find that Ameripol Micro-Black saves time and money in three important ways ■ IN PRODUCTION Micro-Black eliminates time consuming weighing and milling operations... shortens mixing operations ■ IN STORAGE Micro-Black is packaged for easy fast handling... eliminates in-plant storage of carbon black ■ IN PRODUCTS Micro-Black assures thorough dispersion of carbon black in the rubber... increases abrasion resistance, cuts heat build-up ■ Shown here are just a few ways Goodrich-Gulf's remarkable Masterbatch helps make better rubber products faster and at lower cost ■ To put Micro-Black to work in your own operation, call or write us at 1717 E. 9th Street, Cleveland 14, Ohio.



GOODRICH-GULF CHEMICALS, INC.,
World's largest source of synthetic rubber

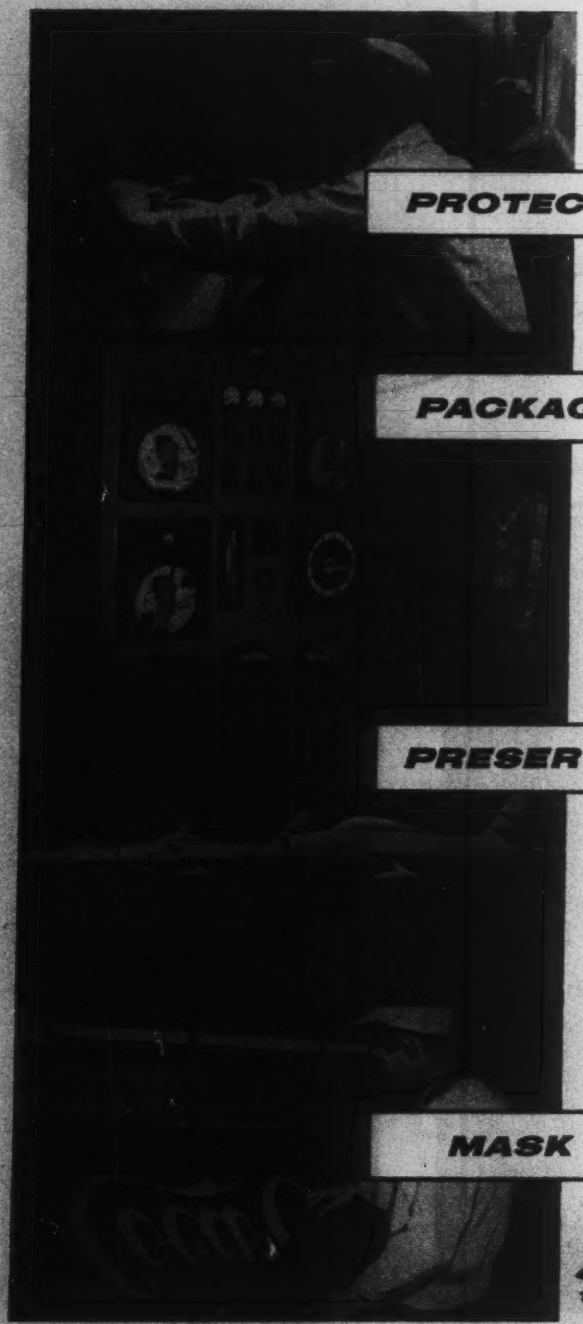




For more information, turn to Reader Service card, circle No. 361

SPRAYLAT
SPRAY-ON STRIP-OFF COATINGS

Protect, package, preserve and mask with Spraylat and cut your costs, save time, reduce damage in your plant. Find out today about the hundreds of unusual problems Spraylat coatings have solved successfully throughout industry. Write for complete data, stating your application. We will engineer a spray-on strip-off solution for you.



PROTECT

An outstanding example—all the curtain wall panels on the Union Carbide Building, New York City, were protected during fabrication, lamination and installation, for eighteen months by Spraylat coatings. Spraylat can be used effectively to protect any metal surface, painted or unpainted, against the weather and damage from scratching, paint overspray and cement.

PACKAGE

Complex electrical and electronic panels are a good example of the kind of packaging protection Spraylat offers manufacturers who desire to end repainting and touch-up problems. Spraylat-protected products remain scratch-free during manufacture, shipment and storage.

PRESERVE

For the first time a strippable coating system is available for the temporary protection of aircraft, missiles, vehicles and spare parts during storage and shipment, which can be sprayed directly on all surfaces including paint, rubber, plastic and metals. This coating air dries to form a tough, rubbery good aging waterproof peelable film. It meets military specifications.

MASK

Spraylat's spray-on strip-off water based coating is used extensively by the sign industry to mask both plastic and metal signs. Areas of the film are scored, peeled and the remaining film acts as a perfect mask against lacquers, enamels, and even metallizing, enabling mass production by spray painting methods.

SPRAYLAT CORP.
"Quality Protective Coatings Since 1937"
One Park Avenue, New York 16, N. Y.

For more information, turn to Reader Service card, circle No. 408

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Steel *for Strength . . . Economy . . . Versatility*

Flame-Hardening Alloy Steels

The process known as flame-hardening involves the direct application of flame to the surface of steel, heating it above the transformation range, then hardening it by quenching. The primary purpose of this process is to achieve surface-hardness without affecting core properties. Jets of flame are played directly on the steel, and hardness penetration can be made to vary considerably. In alloy steels this depth will range usually from 0.03 to 0.12 in., the actual figure depending upon the method of heating and quenching used.

Unlike carburizing, flame-hardening does not involve the absorption of extraneous elements by the steel. There is no alteration of the chemical composition. To put it simply, the steel must have its own self-hardening characteristics; it cannot be dependent upon carbonaceous salt baths, gases, and other media.

Flame-hardening is not a substitute for the conventional furnace method. Each has its uses. The particular virtue of flame-hardening is that the flames can be directed to localized areas. The furnace, on the other hand, is generally more economical and feasible when parts produced in large quantities must be hardened all over.

Any type of hardenable steel, alloy or carbon, can be flame-hardened, and there will usually be no scale or pitting. The alloy content is the governing factor when determining the quench. In some cases a rapid quench is required; in others, it can be as slow as air-cooling. Tempering presents no problems, for flame-hardened steel can be tempered as if hardened to the same degree by other methods.

A list of typical flame-hardened parts includes such familiar items as gear and sprocket teeth, and certain types of cams and rollers, and shoe treads. A complete list would include many other parts that often require a localized hardening treatment, especially for wear-resistance.

When you need information about flame-hardening methods, please feel free to consult with our technical staff. Bethlehem metallurgists will work with you, at no obligation, and you can depend on their suggestions. You can rely on Bethlehem, too, as a source of alloy steels . . . for Bethlehem makes the complete range of AISI standard grades, as well as special-analysis steels, and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

What's News in Rubber...

ENJAY BUTYL HT 10-66 gives this playground mat the ability to withstand years of scuffing and abrasion, repeated impacts and flexing, as well as outdoor weathering.

A NEW RUBBER TO DO THE HARD JOBS!

ENJAY BUTYL HT 10-66

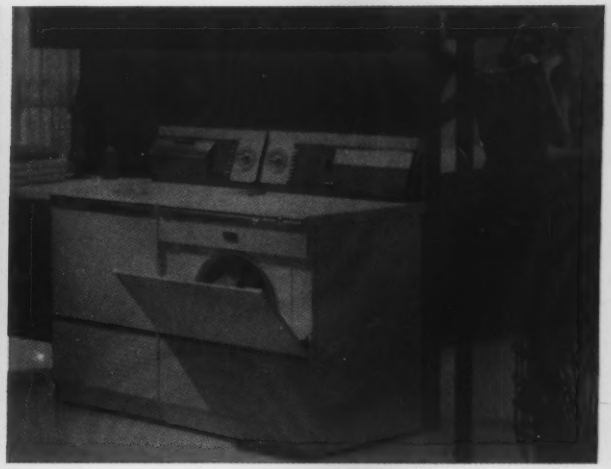
Halogenated for...high heat resistance...covulcanization with other elastomers... low compression set... and faster cures

Plus these well-known Butyl advantages:

- *High flex, tear and abrasion resistance*
- *Low gas and moisture permeability*
- *Excellent chemical resistance*
- *High weather and ozone resistance*

NOW AVAILABLE IN A VARIETY OF MOLECULAR WEIGHTS

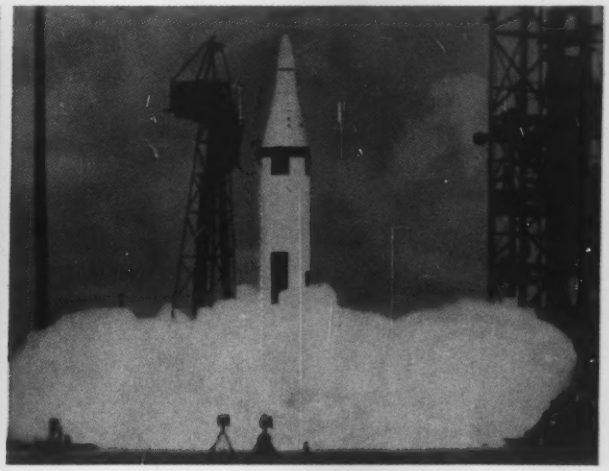
AIR-HOLDING INNERLINERS of Enjay Butyl HT 10-66 help assure correct inflation pressure for tubeless tires and can give greater blowout protection as well as improved tire-tread wear. Other tire uses include white sidewalls, black sidewall veneers and chafer strips.



APPLIANCE PARTS of Enjay Butyl HT 10-66 withstand the deteriorating effects of detergents and dishwashing compounds. Absorption of hot water by the rubber is reduced to a minimum.

HOT MATERIAL BELTS like this perform well at continuous temperatures of 350°F, thanks to the exceptional heat aging properties of Enjay Butyl HT 10-66.

SHOCK-RESISTANT LAUNCHING PADS of metal-covered Enjay Butyl HT 10-66 withstand launching shock and exposure to intense heat encountered in missile firings.



WRITE TODAY FOR NEW TECHNICAL MANUAL HT 10-66...

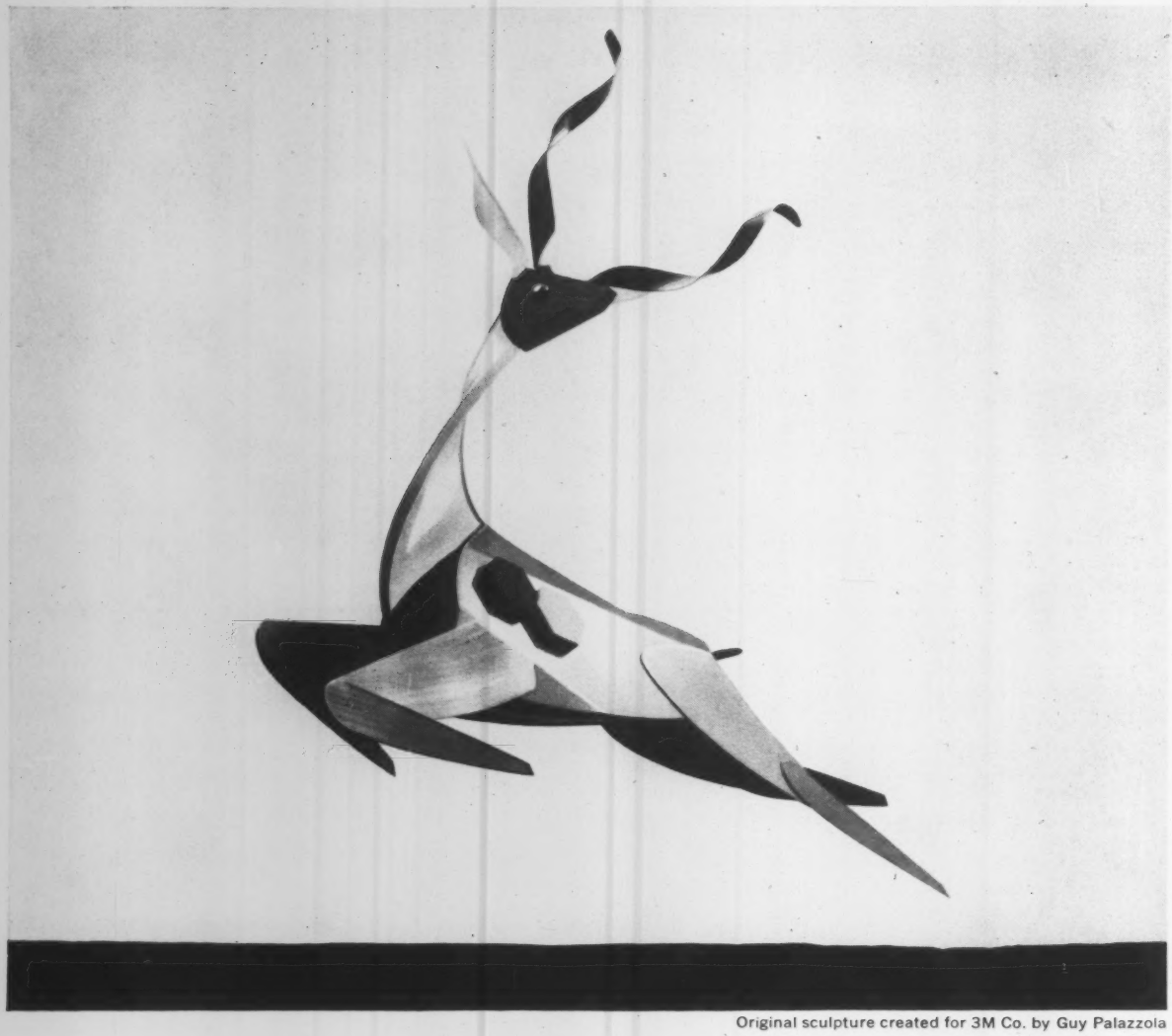
Contains processing information, performance data and recommended cure systems. For your free copy or for technical assistance in applying this important new polymer, write to Enjay, 15 West 51st St., New York 19, N. Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY® BUTYL



Original sculpture created for 3M Co. by Guy Palazzola

Freedom

. . . New design concepts "take off" with 3M Brand Adhesive Products!

Want to escape design limitations imposed by old-fashioned fastening ways? Help yourself to new elbowroom with the modern, clean-lined, functional fastening you get with 3M Adhesives!

New simplicity! Using 3M Adhesives for assembly, you eliminate fasteners, nuts, bolts, rivets, staples. Fewer parts give you simpler construction that costs less, looks better. The making of necessarily complex shapes and castings, too, is simplified by 3M Adhesives; you break down the complex part into several simple sections, then adhesive-bond into one.

New material choices! With 3M Adhesives you bond practically any material to itself or to any other material. Metals (including magnets), woods, glass, ceramics, plastics, the whole works! Lighter gauge materials can be used because adhesives eliminate local stress concentrations, increase joint strength. The integrity of joined materials is unimpaired because holes (for fastening devices) and heat (for fusion) are eliminated.

New production savings! With the increasingly close liaison between industrial designer and production engineer, the many production savings inherent in adhesive bonding favor the design that employs 3M Adhesives. For a realistic appraisal of what 3M Adhesives can do to give you more design freedom, better production economics, call your nearest 3M Field Engineer or write to: AC&S Division, 3M Company, Dept. SBHH-71, St. Paul 6, Minn.

What do you want to bond to what?

The 3M Gazelle is fabricated of these materials and bonded with 3M Adhesives, including SCOTCH-WELD® Brand Structural Adhesives:

1. Brass 2. Wood 3. Plastic 4. Ceramic 5. Copper 6. Stainless Steel 7. Aluminum.

"SCOTCH-WELD" is a Reg. T.M. of 3M Co. © 3M Co., 1961

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

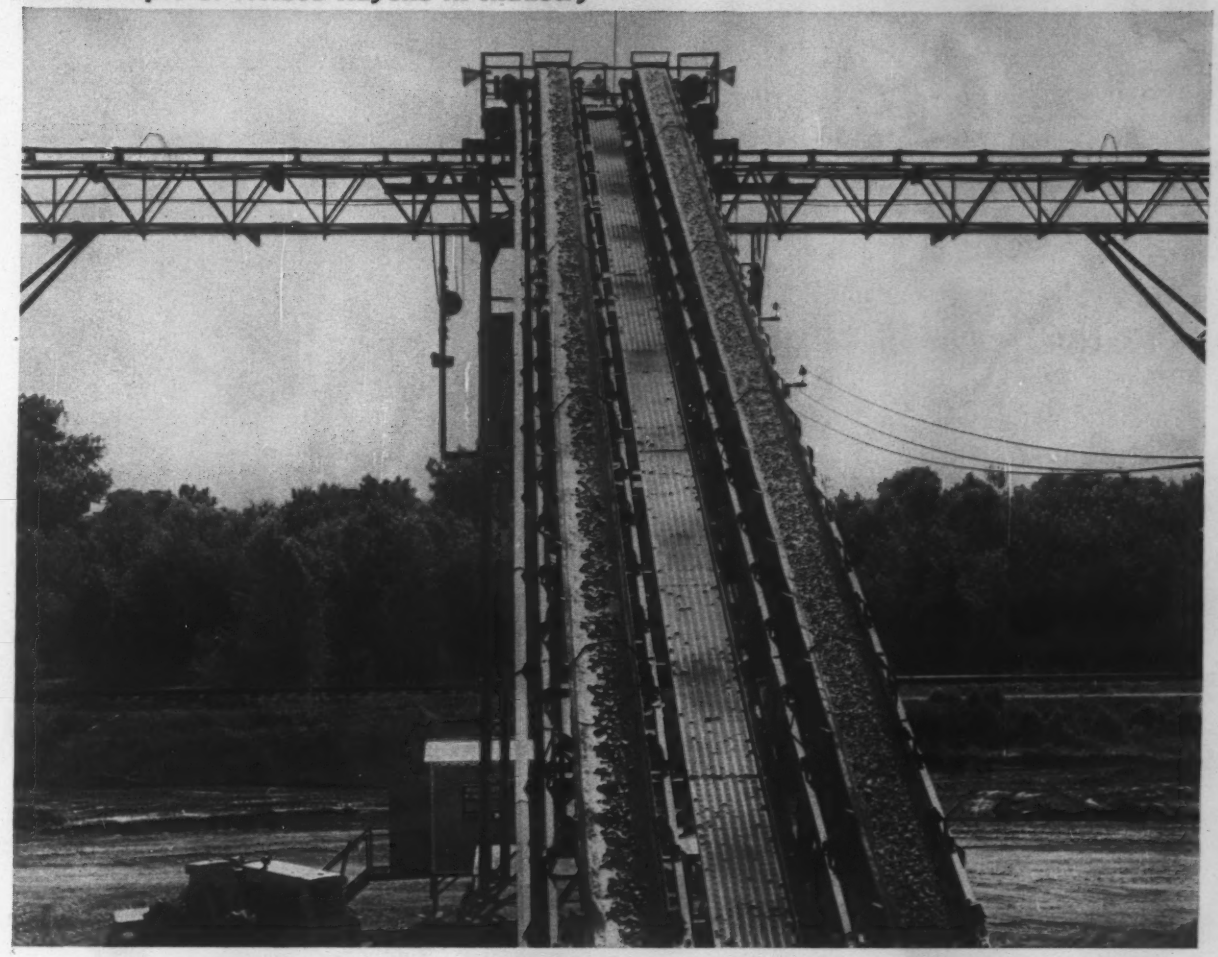
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

For more information, circle No. 422

For more information, turn to Reader Service card, circle No. 411

An example of Avisco Rayons in Industry



Now, stronger, lighter-weight belts with Avisco XL-I rayon

Because of fabrics made from Avisco XL-I rayon fiber it is now possible to engineer stronger, lighter-weight belts.

Compared to the traditional fiber, fabrics of XL-I rayon have up to 60% greater tensile strength and 3 to 5 times the fatigue life.

XL-I rayon adheres without predipping. Flex characteristics are excellent. XL-I fabrics trough well, conform better to pulleys and rollers, readily absorb starting and shock loads. Their lighter weight requires less power for starting and running.

For help in improving your product with Avisco XL-I rayon reinforcement, send in the Quick Reply Coupon.

QUICK REPLY COUPON 3-4

Industrial Merchandising Division
American Viscose Corporation
350 Fifth Avenue, New York 1, N. Y.

Please contact me about Avisco Rayons for use in the following application:

_____

Name_____

Company_____

Address_____

City_____ Zone____ State_____

AVISCO® RAYON

AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

For more information, turn to Reader Service card, circle No. 352

...keeps rockets from burning their tails!

These four Panelyte® nozzle liners insulate against temperatures *in excess of 5000°F.* and resist the erosive effect of supersonic exhausts on America's missiles.

This *one-piece*, high-density molding was "too big to be produced." It's a full 28" wide by 10" deep by 1¾" thick . . . includes separate layers of refrasil and graphite in heat-resistant phenolic resins . . . and is absolutely free of pinholes and voids.

Panelyte's ability to produce such high-pressure moldings has been demonstrated on parts weighing from a few ounces to over 200 pounds. It can meet such unique product requirements because Panelyte has:

- Forty-five presses in the 160-3000 ton range, including presses with daylights of over 100 inches.
- Over two decades of experience in complex mold design.
- Complete facilities for testing both the electrical and mechanical properties of all types of plastics.
- A completely equipped pilot plant for resin studies, impregnation and development of molding techniques.
- Over 200,000 square feet of plant space devoted exclusively to the production and fabrication of high-pressure moldings and laminated plastics.

Our engineering and development group stands ready to work with you in designing and supplying high-pressure moldings and laminates for your particular application.

Why don't you start the ball rolling . . . *now?* Contact the Panelyte Division, St. Regis Paper Company, North Enterprise Avenue, Trenton, New Jersey.

Panelyte also produces laminated plastic sheets, rods, tubes and copper-clad stock, as well as special laminates and fabricated parts.

St.Regis PANELYTE®

For more information, turn to Reader Service card, circle No. 432

Wind Velocities to Mach 7 Prove Needle-Size Superior Stainless Tubing

Manometer lines of Superior Type 304 stainless tubing, drawn to needle size, withstand the vibration caused by air speeds beyond Mach 7 and internal pressures as high as 5000 psi in FluiDyne wind-tunnel tests of missile component models. And they have been in some assemblies for 3½ years without cracking, pinholing or buckling.

FluiDyne Engineering Corp., one of the major designers of such test facilities, attributes the long life of this Superior tubing to both its high modulus of elasticity and its resistance to the corrosive effects of mercury and soldering-flux acid.

Ductility is a big advantage, too. This permits the Superior tubing to be easily hand-bent into complex shapes for application in wind tunnels and readout equipment.

Filling stainless steel tubing orders that call for tiny needle tubing in gages from 6 to 33 or tubing with OD's as large as 1.125 in. calls for the resources Superior has to offer. Why not investigate us as a source of small-diameter stainless tubing. Catalog 21 describes the types and analyses available. Also gives tips on its selection and application. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

For more information, turn to Reader Service card, circle No. 374

Machining greatly reduced by concentricity of

REPUBLIC ELECTRUNITE MECHANICAL TUBING

CRITICAL PART IN POWER STEERING PUMP made with Republic ELECTRUNITE Mechanical Tubing. Keyed bushing fits over engine crankshaft, provides pump drive for power assist. Close tolerance machining is essential for dual mechanical-hydraulic function.

Precise concentricity of ELECTRUNITE Mechanical Tubing solved a machining problem and cut costs for Eaton Manufacturing Company, manufacturers of power steering pumps.

At the heart of the power steering pump is a bushing made from heavy wall ELECTRUNITE which serves as the internal shaft of the unit. It fits on the crankshaft of the car and drives the power steering pump.

The tubing is ground on both the ID and OD. A keyway is broached on the ID the entire length of the part, approximately 2⅝ inches. Another keyway is then milled on the OD.

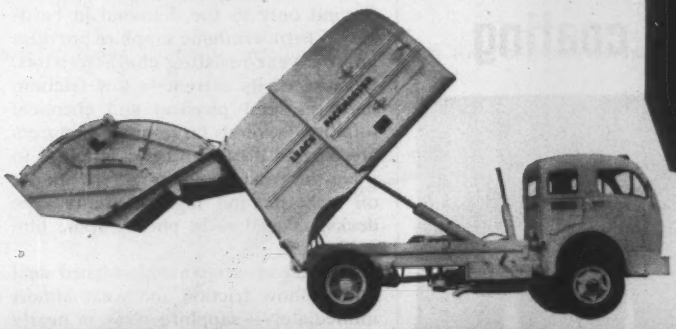
Since Eaton must work to very close tolerances on the part, concentricity of the OD and ID of the tubing are most important to minimize machining.

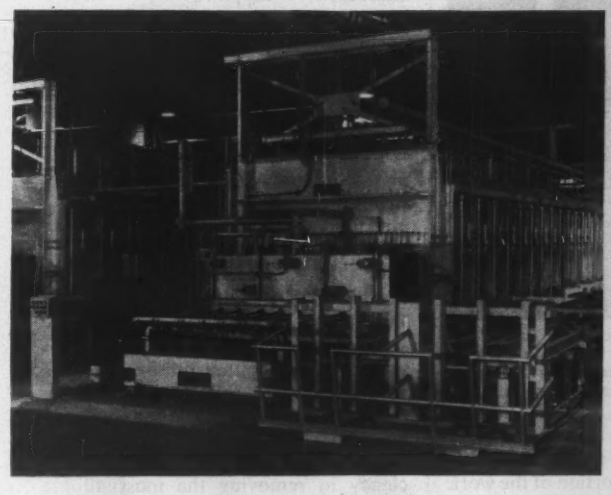
In addition, as it is part of a hydraulic system, the steel must be structurally sound without flaws of any sort.

This is another example of how precision fabricated Republic ELECTRUNITE provides high quality and cost savings for critical applications.

ELECTRUNITE is available in a wide range of sizes, gages, and wall thicknesses in both carbon and stainless steels to meet your needs. For full information call your Republic representative or send coupon below.

COLD FINISHED ALLOY BARS form high strength pins to carry the full weight (up to 5 tons) of this Packmaster body and its refuse load when unit is hoisted to unload. Republic Cold Finished Alloy Bars, cut off, drilled, and chamfered by Leach Company, Oshkosh, Wisconsin, manufacturers of the Packmaster, offer the toughness and abrasion resistance necessary in this application. Investigate the advantages of using Republic Cold Finished Alloy Bars for your component parts production. Mail coupon.





NEW ANNEALING FURNACES provide maximum heat treating capacity for cold extrusion steel. Quality of steel produced at the Chicago Bar Mill attains a high level of uniformity through heat treatment in two new atmosphere-controlled annealing furnaces. These new furnaces provide the capacity to assure prompt delivery of orders for heat treated steels.

BENDING, FLANGING, SEAMING—ductile zinc coating on Republic Galvannealed Sheets stays tight, resists flaking, peeling, or spalling. Hot dip galvanizing plus special heat treatment give Galvannealed a graduated coating of iron—zinc alloys between the pure zinc outer surface and the base metal. The tough, uniform protective finish that is spangle-free provides a good paint base, withstands temperatures to 750°.

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

Strong, Modern, Dependable

For more information, circle No. 323

REPUBLIC STEEL CORPORATION
DEPT.ME-2199
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send me more information on the following products:

- ☐ Republic ELECTRUNITE® Mechanical Tubing
- ☐ Republic Steel for Cold Extrusions
- ☐ Republic Cold Alloy Bars
- ☐ Republic Galvannealed Sheets

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

Linde Coatings & materials News

LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION

Surgical shears get longer life with LINDE tungsten carbide coating

Surgical shears with tungsten carbide coated on working surfaces now lose their cutting edge about *one-third* as fast as conventional shears. This has been proven under rigid testing supervised by a leading research laboratory.

The American Medical Instrument Corporation, Flushing, New York, uses the LINDE Flame-Plating process to improve the working surface and increase the wear-resistance properties of shears produced under its *Tuncarb* trade-mark.

The process has increased cutting life to the extent that *Tuncarb* shears in use for more than a year have not as yet been returned to AMICO for sharpening. By comparison, regular surgical shears used under the same conditions had to be returned as many as three times for restoration of working surfaces.

Coatings only .004" thick

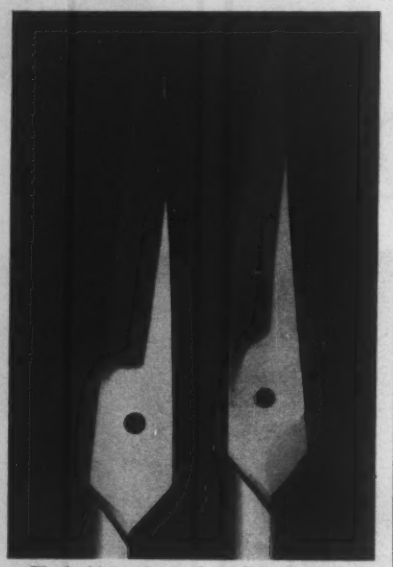
AMICO ships hot-drop-forged stainless steel parts to LINDE's new Flame-Plating plant at North Haven, Conn. Here, via the LINDE developed coating process, a .004" thickness of tungsten carbide is actually "welded" to the precision wear surfaces of the instruments.

After coating, the blades and jaws are assembled, riveted, ground, polished, and buffed to a high finish by AMICO. The tungsten carbide surfaces themselves are finished with only a slight brushing. The same process is used to coat *Tuncarb* needle holders to provide tungsten jaws that give a firm grip on needles.

High-speed "blast-on"

The heart of LINDE's coating process is the LINDE Flame-Plating gun, into which exact quantities of oxygen, acetylene, and tungsten carbide or other powdered materials are fed by a special mechanism. After the gun is aimed at the area to be coated, controlled detonations "blast" the particles onto the work piece at speeds up to 2500 fps—until the desired coating thickness is reached.

Although temperatures of about 6000° F are attained within the detonation gun to heat powder to plastic state, the work piece itself is always kept below 400° F during the operation. There are no changes in the properties of the base metal and no distortion of the work piece regardless of its minuteness.



The inside cutting surface of the *Tuncarb* surgical shears shown here have been coated with tungsten carbide, reducing their rate of wear by as much as one-third.

In some uses, depending on the thickness of finish, the LINDE Flame-Plating process has been known to multiply wear resistance of metal parts by as much as 40 times.

For complete information on how you might use this advanced method of coating metals to improve production or reduce operating costs, check and send the coupon below.

LINDE synthetic sapphire solves guide problem in tape recorders

Second only to the diamond in hardness, LINDE synthetic sapphire provides unique wear-resisting characteristics. Because of its extremely low friction, hardness, and physical and chemical stability, several large manufacturers are using LINDE synthetic sapphire to solve the wear problem in tape guides on airborne and high-reliability tape decks, as well as in photographic film guides.

In these areas—where hardened steel guides show friction and wear almost immediately—sapphire wear is nearly imperceptible even after 100 hours of operation.

LINDE flame-polished synthetic sapphire is a convenient material for preventing edge-cutting typical with certain tapes in top and bottom guides.

For details on LINDE synthetic sapphire for any type of wear guide, instrument bearing, or other critical application, check and mail the coupon.

Chromium polished to maximum lustre with LINDE abrasives

In certain applications where it is necessary to achieve an extremely smooth surface on chromium finishes, such as in photographic rolls and processing rolls in the plastics industry, LINDE alumina abrasive powders of 99.98% purity have demonstrated unusual efficiency in removing the most minute protuberances.

Several leading photographic and precision parts manufacturers use LINDE abrasives, not only to obtain high-lustre finishes that protect materials, but also to refinish rolls several times over to avoid frequent replating.

Grades of LINDE alumina powders in sub-micron sizes are available for several cutting speeds or types of finish. For information, use the coupon below.

CHECK—CLIP COUPON—ATTACH TO BUSINESS LETTERHEAD

Linde Company, Dept. MI-07
270 Park Avenue
New York 17, N. Y.

Please send details on the items checked:

- ☐ LINDE Flame-Plating
- ☐ LINDE Synthetic Sapphire
- ☐ LINDE Alumina Abrasives

UNION CARBIDE

LINDE COMPANY

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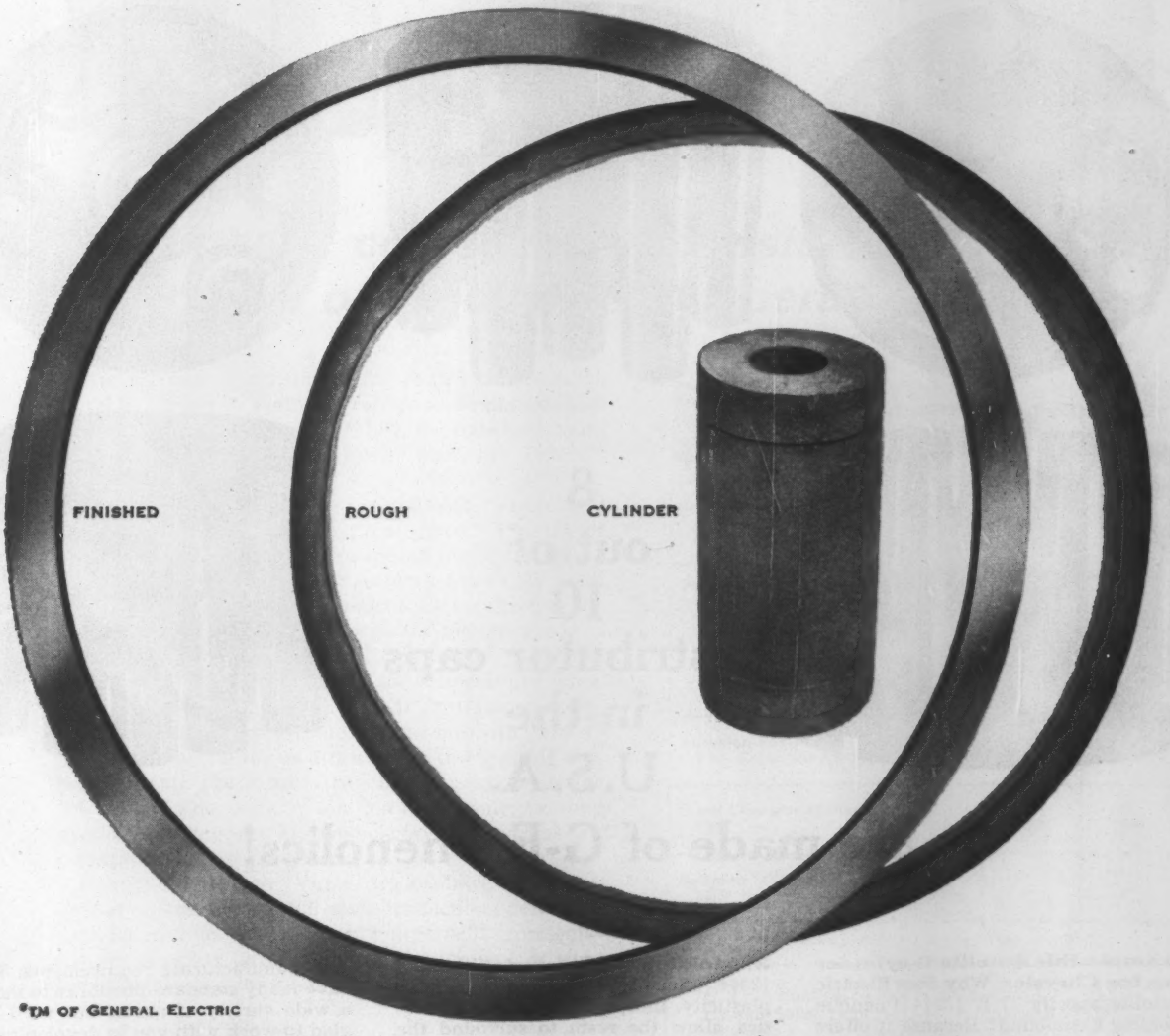
For more information, turn to Reader Service card, circle No. 434

NOW—A WELD-FREE RENÉ 41* RING DEVELOPED BY C-M TO ELIMINATE THE PROBLEMS OF WELDED RINGS.

C-M'S RENÉ 41 RING IS FORGED FROM A CYLINDRICAL CASTING INSTEAD OF ROLLED FROM BAR STOCK AND WELDED. THIS INTEGRAL, WELD-FREE RENÉ 41 RING IS THE RESULT OF A CASTING PROCESS DEVELOPED BY C-M USING A THIN CROSS-SECTION RATHER THAN THE CONVENTIONAL THICK INGOT. BECAUSE THE CROSS-SECTION IS THINNER, IT COOLS QUICKER. THIS FAST COOLING PREVENTS SEGREGATION OF ELEMENTS—ELIMINATES STRINGERS. GRAIN SIZE IS MORE UNIFORM, TOO, AND THE RING HAS GREATER HOMOGENEITY THAN RINGS PRODUCED BY OTHER METHODS.



*TM OF GENERAL ELECTRIC

C-M'S PROCESS CAN HELP SOLVE YOUR RING PROBLEMS ON RENÉ 41 AND OTHER DIFFICULT-TO-FORGE IRON, NICKEL AND COBALT ALLOYS. WRITE TODAY FOR COMPLETE INFORMATION.

ULTRAMET VACUUM ALLOYS

CANNON-MUSKEGON CORPORATION

METALLURGICAL SPECIALISTS • 2873 LINCOLN STREET • MUSKEGON, MICHIGAN

For more information, turn to Reader Service card, circle No. 349

8 out of 10 distributor caps in the U.S.A. are made of G-E Phenolics!

Example: this Autolite 6-cylinder cap for Chrysler. Why does Electric Autolite specify G-E 12944 Phenolic Molding Compound? Because it offers the best possible combination of performance and molding characteristics for Autolite's line of distributor caps:

1. Performance—Physical properties of the G-E 12944 parts include dimensional stability, resistance to carbonization (tracking), and ability to stand up under extremes of cold and heat (–40F to 250F). The phenolic has good electrical properties and is able to take rough handling, vibration and shock.

2. Molding Characteristics—G-E 12944 phenolic compound has good plasticity. Its special flow characteristics allow the resin to surround the multiple metallic inserts quickly and completely without disturbing their position and to fill the intricate distributor cap mold rapidly. G-E 12944 cures quickly. It permits short molding cycles — a necessity for this mass-production part.

General Electric has tailored this compound specifically for automotive use. It is an example of the care and effort we expend in formulating a compound to meet individual engineering and manufacturing requirements. We have many standard phenolics to meet a wide variety of needs, but we'll be glad to work with you in developing a special formulation to meet *your* specifications. For more information write to: General Electric Company, Section M-461, Chemical Materials Department, Pittsfield, Mass.

Phenolics-first of the modern plastics...first in value

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 407

New from Du Pont—

FABRICS COATED WITH

VITON®

A synthetic compound that resists abrasion, corrosion, oils, solvents, temperature extremes

There are new opportunities for coated fabrics when durable "Viton"* synthetic rubber is combined with fabrics of glass, "Armalon"* TFE-fluorocarbon resin-coated glass, "Dacron"* polyester fiber, or "Teflon"* TFE-fluorocarbon fiber.

For example, a glass fabric coated with "Viton" and laminated to Refrasil fabric ("Fairprene"* 85-002) for use as a missile screen, when exposed for 60 seconds to 5700°F., 1½ inches from the surface, shows only slight charring of the Refrasil and practically no effect on the "Viton" coated glass which forms the alternate side of the laminate. "Viton" maintains its elastomeric properties despite this heat...can also withstand temperatures as low as minus 40°F., in gauges up to .020", without cracking.

An "Armalon" fabric coated on one side with "Viton" has proved promising as a tubing for transporting corrosive gases. These tubes can be heat-sealed on the "Armalon" side, with "Viton" on the outside, assuring excellent resistance to heat and chemicals as well as low permeation loss of the gases.

Fabrics coated with "Viton" are available for experimentation, test runs, or full-scale production operations. Contact your nearby Du Pont "Fairprene"* representative for complete information, or send coupon at right for literature and information.

*Du Pont registered trademarks.

PHYSICAL PROPERTIES OF FABRICS COATED WITH "VITON"

	86-007	85-001	84-001
Description: Polymer Fabric	"Viton" A "Teflon"	"Viton" A #116 Glass	"Viton" A "Dacron"
Properties: Gauge	.020"	.011	.008"
Wgt., Oz./Sq. Yd.	22	15	9
Tensile Strength Strip, Lbs./Inch, W x F	77 x 73	117 x 90	81 x 70
Tear Strength Trap., Lbs. W x F	16 x 13	1 x 1	2 x 3
Abrasion Resistance 1 Lb. Edgewear Strokes	10,000	10,000	10,000
Burst Strength, Mullens, PSI	168	172	158
Gehman Stiffness T10* °F.	3°	3°	3°

*Temperature at which it is 10 times as stiff as at 77° F.

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Sales, Dept. MD-17, Wilmington 98, Delaware.

Please send literature on fabrics coated with Du Pont "Viton" synthetic rubber.

*Name*_____ *Position*_____

*Company*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

Du Pont Industrial Coated Fabrics

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

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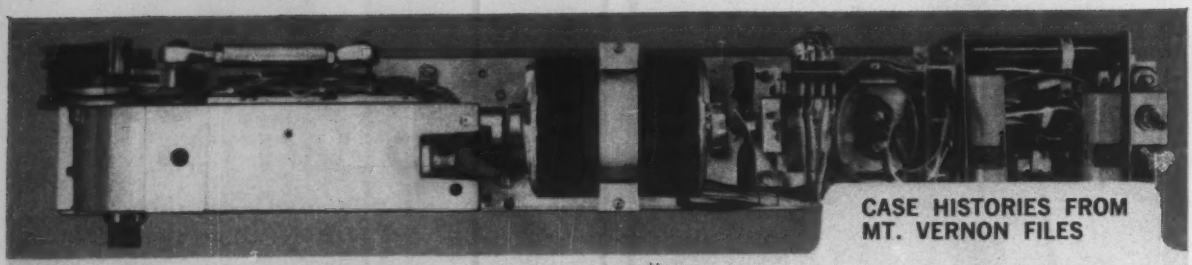


CASE HISTORIES FROM
MT. VERNON FILES

The STANLEY® MAGIC-DOOR Electric Operator . . . another open and shut case for die casting— . . . MT. VERNON die casting

From Stanley* comes this new electric, automatic door opener, compact and economically priced and amply powered to handle all new or existing doors up to 42″ widths — weights up to 150 lbs.

The Operator, a compact power package, measures only 5½″ x 6″ x 31″— weighs less than 40 lbs. — contains 5 major assemblies including a transmission which is the muscle. Although the transmission case is somewhat smaller than an ordinary shoe box, it contains all the gears, cams, bearings, linkages, etc. for converting the high speed output of the motor into a mighty and instantly responsive door-swinging thrust.

Shown here are the 5 Mt. Vernon die castings which make up the transmission case—3 cover plates—1 bridge plate and 1 main housing. Your practised eye will tell you that the latter is a very complex casting — a compact casting designed with enormous built-in strength to meet its service load strains.

Producing castings of this nature is never easy — but rarely a problem at Mt. Vernon for we offer manufacturers more than die casting production. Ours is a four-fold service • designing, die making, casting and machining • a coordinated service — all under one roof in 200,000 sq. ft. of space. The most advanced independent die casting plant in the country.

Complex or simple, why not bring your die casting problems to us. What we do for Stanley and others we can surely do for you. Just call your nearest Mt. Vernon Field Salesman or our home office.

*The Stanley Works, New Britain, Conn.

MT. VERNON DIE CASTING CORPORATION

Stamford, Connecticut

FIELD SALESMEN—BALTIMORE, MD.: Mr. C. M. Gordan, 919 St. Paul St. • **BROOKLYN, N. Y.:** Mr. Robert V. Moore, 2317 Plumb 2nd St. • **MARIETTA, N. Y.:** Mr. Burt J. Meldrum, Olanco Road • **PITTSBURGH, PA.:** Mr. Andrew W. Anderson, 300 Pasadena Drive So. • **STAMFORD, CONN.:** Mr. Anker Anderson, Cascade Road • **VALLEY FORGE, PA.:** Mr. G. T. McMaster, P. O. Box 115

For more information, turn to Reader Service card, circle No. 363

PRODUCT-DESIGN BRIEFS FROM DUREZ

- Hetron® for outboard motor shrouds
- Plastic potentiometer
- Dip-coating compounds

Great for waterways

One key advantage of Hetron polyester resins is durability under stress. This quality turns out to be particularly pertinent for Gale Products, a division of Outboard Marine Corporation.

In the outboard motors produced by this Illinois firm, shroud permanency was a problem. The solution was to make them of Hetron reinforced with fibrous glass. A critical step in the production process consists of two baking operations at 240°F. The material takes the bakes without crazing.

In use the shrouds won't crack,

GALE PRODUCTS

craze, or corrode. They resist denting and abrasion, have high impact strength, are lighter than metal covers (about 3 lbs. lighter in the case of a 50-hp motor), protect motor parts from water spray, are about 15% less expensive to produce than metal covers.

An additional benefit is the transformation of the motor's roar to a pleasant purr, which permits boaters to enjoy conversation with their sport.

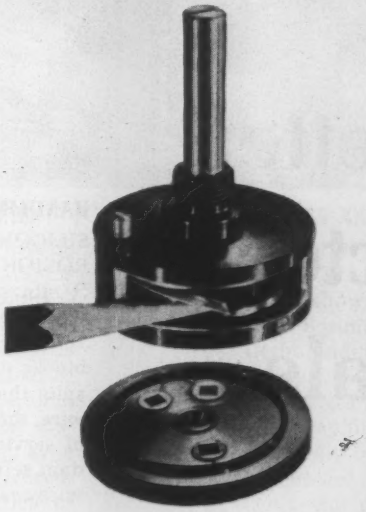
Hetron resins have properties that make for superior performance in a wide variety of applications. We'll be happy to send you detailed information on this family of premium polyesters.

Look—no coils

Get to the heart of a new and better product, and often you'll find a Durez plastic.

For instance: this little precision potentiometer. It's better because it's simpler—contains no resistance wire, no varnish, no cement to come unstuck and cause failure.

Instead, the metallic wiper (at pencil point) rides on an almost friction-free plastic ring, the resistance element. The



NEW ENGLAND INSTRUMENT CO.

ring is made of diallyl phthalate resin mixed with carbon. The buttonlike insulating base is a standard Durez diallyl phthalate molding compound.

Potentiometers made with these materials just don't seem to wear out. Nor do they lose their excellent insulation properties in clammy surroundings. For these reasons, the little instruments are being specified widely for missile and rocket control systems, computers, and servo gear.

When your design project needs a moldable material of far-better-than-average electrical properties—*plus* resistance to moisture and heat—think of Durez diallyl phthalate molding compounds. We'll gladly send you facts about them.

Coat for components

Looking for a simple encapsulating idea? Here's one that works well at heatproofing, moistureproofing, and preventing shorts in small electrical components. It's non-messy, too.

Dunked in a paste coating, dried, then baked for a short time, components steadfastly resist extremes of heat and moisture that would otherwise raise havoc with their electrical reliability.

Components so coated can be soldered into a circuit without causing the coating to melt or peel. It won't soften, and easily passes a series of −55 to +85°C cycles. One thousand hours at a sweltering 150°C will turn the coating almost black, but still won't materially affect the component inside.

The paste is made with Durez phenolic resin-and-filler compounds supplied in powder form. After baking, it is impervious to ketone solvent cements sometimes used in assembling radio and TV chassis.

What can these dip-coating compounds do for you? We'd like to help you find out. Write for more detailed information.

For more information on Durez materials mentioned above, check here:

- ☐ Bulletin D-6: properties and applications of Hetron fire-retardant resins
- ☐ Data sheets: facts about diallyl phthalate molding compounds
- ☐ Data on phenolic resin compounds for dip-coating

Check, clip and mail to us with your name, title, company address.

DUREZ PLASTICS DIVISION

1407 WALCK ROAD, NORTH TONAWANDA, N. Y.

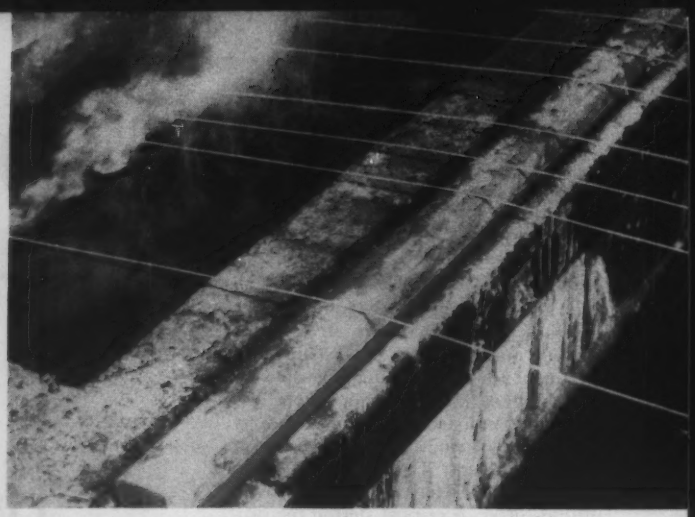
HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 343

Report from Carborundum:

6 ways to do jobs better with refractory materials



HANDLING MATERIALS IN ACID SOLUTIONS:

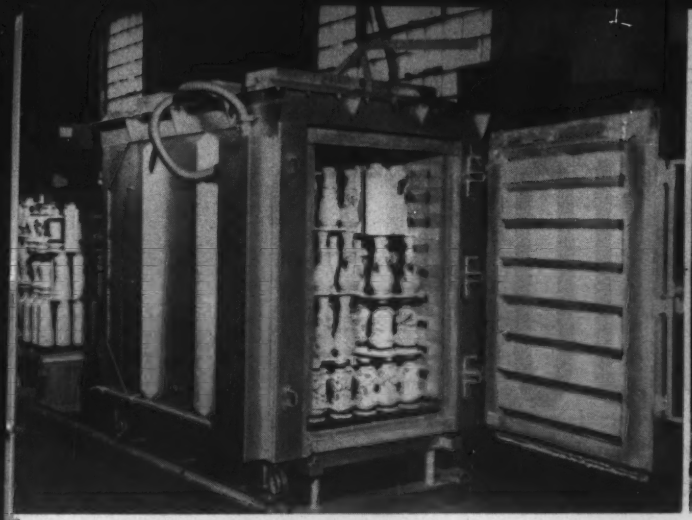
SILICON CARBIDE WEAR BLOCKS RESIST CORROSION AND ABRASION. Steel wire moving at 100 ft/min passes over CARBOFRAX® silicon carbide wear blocks to a pickling tank in the photo above. A 15% solution of sulfuric acid at 400 F is used. Sinker blocks are also of CARBOFRAX silicon carbide. Despite the action of the acid and the abrasion of the wire, the silicon carbide shows no wear after months of service. Similar applications involving Carborundum refractories are found in aluminizing and other wire coating baths.

SKID RAILS IN REHEAT FURNACE:

SILICON CARBIDE RAILS LAST 30 TIMES AS LONG AS STEEL IN HIGH TEMPERATURE, ABRASIVE SERVICE. The 6¾" x 8" brass billets seen in the picture are pushed through a 38-foot long gas-fired extrusion mill furnace. Steel skid rails required replacement every five weeks. When CARBOFRAX silicon carbide rails were installed, 156 weeks of service were obtained. Reduction in downtime resulted in lower operating costs and higher production rates. Superior wear resistance and ability to withstand high temperatures make silicon carbide a profitable choice for applications like this.

LONGER LIFE FOR BURNER RINGS:

SILICON CARBIDE CONSTRUCTION WITHSTANDS FLAME EROSION AND HIGH TEMPERATURES. Refractory burner rings in pulverized coal-fired boiler frequently fail fast because of the abrasive action of the fuel particles and thermal shock due to intermittent operation. Many users have found an answer to the problem in CARBOFRAX silicon carbide rings. Silicon carbide is not only superhard, but also stays hard at high temperatures. High thermal conductivity and resistance to thermal shock minimizes cracking and spalling. Flame patterns are maintained.



DIRT-FREE OPEN FIRING WITH MOVABLE KILN:
FIBERFRAX® CERAMIC FIBER LINING REPLACES BRICK: MAKES POSSIBLE TEMPERATURES UP TO 2200 F. The interesting movable kiln illustrated is made by Unique Kiln Co., Hillsdale, N. J. It moves on rails to enclose a stationary loading bed. Two beds can be serviced alternately. Door and hood linings of Carborundum's light-weight FIBERFRAX ceramic fiber, in block form, eliminate the problem of dislodged dirt and dust encountered with fireclay type refractories, which often damage ware being fired. High heat resistance and insulating properties of FIBERFRAX fiber make possible firing up to 2200 F.

SHAPES AND JIGS MACHINED FROM CERAMIC:
BORON NITRIDE IS EASILY MACHINED; RESISTS HIGH TEMPERATURES AND CORROSION. The photo shows the machining of a semi-conductor jig from Boron Nitride, a self-bonded material made by Carborundum. Close tolerances, high surface finish and intricate detail are possible. Boron Nitride offers advantages in semi-conductor production compared with graphite jigs, yields from which often drop 40% after only 50 cycles. The material also offers possibilities for insulating tubes and shapes; chemical equipment parts, crucibles, brazing fixtures, gaskets and seals. Shapes withstand furnace temperature of 3000 F; powder as high as 5400 F.

ELIMINATING CRACKING IN KILN CAR TOPS:
COMBINATION OF REFRACTORIES SOLVES PROBLEM IN CERAMIC INDUSTRY. Used in a gas-fired electrical porcelain kiln, the cars illustrated have been in service for more than two years at cycles of 14 to 15 hours, operating from cold to 2290 F to cold. Car top cracking due to heat shock has been eliminated by use of three different Carborundum refractories—a bottom layer of MULLFRAX® electric furnace mullite for high load carrying capacity, a middle course of ALFRAX® alumina "bubble" brick for insulation and an upper course of CARBOFRAX silicon carbide tile for resistance to thermal shock.

Want help on your problems?

Carborundum engineers will be glad to recommend refractories to answer your specific needs.

For information, contact Dept. MD-71, Refractories Division, Carborundum Co., Perth Amboy, N. J. Descriptive brochures available on request. Please specify the area or areas of particular interest to you.

for engineered refractories...count on

CARBORUNDUM®

For more information, circle No. 428

HOW TO MAKE 4,999 JOINTS WITHOUT FAIL

Here, with a double tipped oxyacetylene torch, operator brazes condenser coil joints. This condenser-compressor assembly contains 30 hook-up joints, not counting return bends.

The unit evaporator, located inside the house, contains 36 hand-brazed SIL-FOS 5 joints.

International Heater Does it With HANDY & HARMAN SIL-FOS 5

Production statistics of this manufacturer of heating and air-conditioning equipment show that perhaps one in five thousand hand-brazed joints may need touching up. This is a micrometer measurement away from absolute perfection.

One of the Utica, New York, company's products is a home air conditioner that utilizes the existing duct work of the structure's hot-air furnace. Its novelty lies in the fact that the unit's compressor and condenser are located outside the house for noise-free coolness inside the home.

The unit's evaporator is installed on top of the furnace for simple tie-in to the plant's ducting for hot-weather operation.

Shown here in production is International's Model 5-5B of 5 ton capacity.

This "joint in quantity" record is being duplicated by SIL-FOS 5 silver alloy brazing in the manufacture of heating, air-conditioning and refrigeration equipment everywhere. Its strength, air- and leak-tightness and ease of application are some of the reasons that make Handy & Harman SIL-FOS 5 brazing one of the *surest* metal joiners in existence. We'd like you to know more about SIL-FOS 5 and the job it can do for you in joining copper and copper alloys in any shape, size and complexity. Our Bulletin 20 deals with this in a complete and informative manner. A request to Handy & Harman, 850 Third Avenue, New York 22, N.Y. will bring you your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 850 Third Avenue, New York 22, N.Y.

For more information, turn to Reader Service card, circle No. 358

Heat resistant plastic structures with controllable porosity are said to provide a new means of cooling rocket nozzles. The porous material can be made of glass, leached glass, or quartz fabric bonded with a high temperature phenolic resin. Controlling the porosity in the structure provides greater cooling where desired, as at the nozzle throat. Cooling is effected by evaporation, by coolant flowing through the wall, and by the formation of an insulating film inside the nozzle.

Source: Micarta Div., Westinghouse Electric Corp., Hampton, S.C.

A coating of 35% glass, 65% zircon has been found to protect tungsten wire at 3000 F for 10 hr. Other coatings tested and found inadequate included ceramic crystals in a glass matrix, silicide, vapor-deposited silicon monoxide, zirconium, and recrystallizing zirconia glasses.

Source: Report No. PB 171 193, Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C.

A new antifriction material based on polysulfide rubber and epoxy resin is reported by Russian scientists to have tensile and bending strengths equal to those of polyamide and anti-friction plastics. It surpasses them in chemical and wear resistance, adhesive properties, and low hygroscopicity.

Source: *Review of the Soviet Technical Press*, Apr 28, '61, Office of Technical Services, Washington 25, D.C.

Hydrogen embrittlement of tantalum is inhibited by affixing a very small piece of platinum to the tantalum, recent research shows. Alloying or coating is not required. An area ratio of up to 1 to 10,000 prevents embrittlement for more than 1000 hr in concentrated hydrochloric acid at 374 F.

Source: Union Carbide Metals Co., Div. of Union Carbide Corp., 270 Park Ave., New York 17.

A steel tube with an o.d. of 0.00073 in., one-fourth that of a human hair, has been developed in England for the artificial insemination of bees. Tube i.d. is 0.0001 in.

Source: Brackett Steels Inc., Harborside Terminal, Jersey City, N.J.

Printed circuits made by firing molybdenum-manganese patterns on a 97% alumina base are said to withstand temperatures up to 1300 F and forces of 20,000 psi. The strong bond between the circuit path and substrate make it necessary to break the ceramic to separate the circuit. The circuit can operate at high temperatures; carry unusually large electrical loads; and resist arcing, moisture and corrosive liquids.

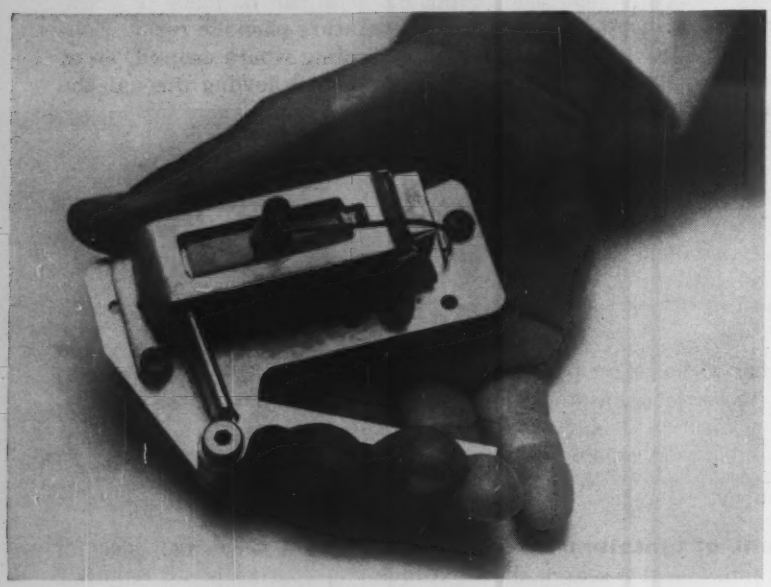
Source: Ceramics International Corp., Mahwah, N.J.

A new electric shaver features a stainless steel head in place of the traditional plated 1095 steel head. Reason: materials engineers found that stainless steel heads are durable, have better corrosion resistance than plated heads, and have good consumer appeal because they can be washed. Nylon 6 has replaced melamine for the case because it has superior toughness, flexibility, shock resistance and moldability, together with lower density.

Source: Schick Inc., Lancaster, Pa.

the LEAD newsletter

Vol. 3 No. 2



Exciting new roles for lead are brought sharply into focus with the introduction of a new ignition system, smaller than a man's fist, that develops a 20,000-volt spark through the application of pressure to two small chunks of a ceramic, lead zirconate-titanate.

The system—dubbed the "spark pump"—does the job of coil, points, condenser and magneto, is already in use in engines of 2¾ to 6½ horsepower for lawn mowers, portable generators, sprayers and pumps for farm and industry.

This application, however, is only the beginning.

Old Phenomenon...New Versatility

The basic principle—direct conversion of mechanical to electrical force (or piezoelectricity)—was discovered in 1880 by Pierre and Jacques Curie, who worked with various crystals.

The discovery, in 1940, that certain ceramics could be permanently polarized promoted the development of piezoelectric ceramics in sizes and shapes not possible with crystals. In the 1950's it was found that the upper temperature limit of these ceramics (about 100° C) could be overcome through the use of lead zirconate-titanate, with limiting temperature around 300° C.

Not only is this lead-based product (65% lead oxide) the most efficient and highest temperature piezoelectric material yet developed, it is also the first successfully to resist depoling under the high pressures necessary.

From Ultrasonics To Fishing

Piezoelectric ceramics for use in ultrasonic cleaning devices are now in large-volume production. Another expanding product area is sonar—underwater counterpart of radar in air—applied militarily for sound-detection, and commercially for locating fish. Depth-finders for pleasure boats are another present sonar application holding promise of growth for the future.

Also currently employing lead-based ceramics of piezoelectric properties are phonograph cartridge elements, fuse elements for detonators, microphones, delay lines, and accelerometers for measuring vibration.

New Ideas By Dozens

Ideas for new products based on the ceramics, says one producer, are coming up so rapidly that merely assessing their merit is quite a sizeable problem. One suggestion: imbed a piece of ceramic in the heel of women's shoes. Each step would generate a spark and light a neon bulb. To what beneficial purpose, the idea's originator does not say—but, women's fashions being what they are, even this notion might sell.

Other ideas, more generally promising, include: spark ignition for oil and gas furnaces, gas stoves and clothes dryers ...electrostatic air filters...atomization of fuel oil...speedometers...and, of course, "spark pump" devices for various gasoline engines, including automotive.

Possibilities in TV Tubes

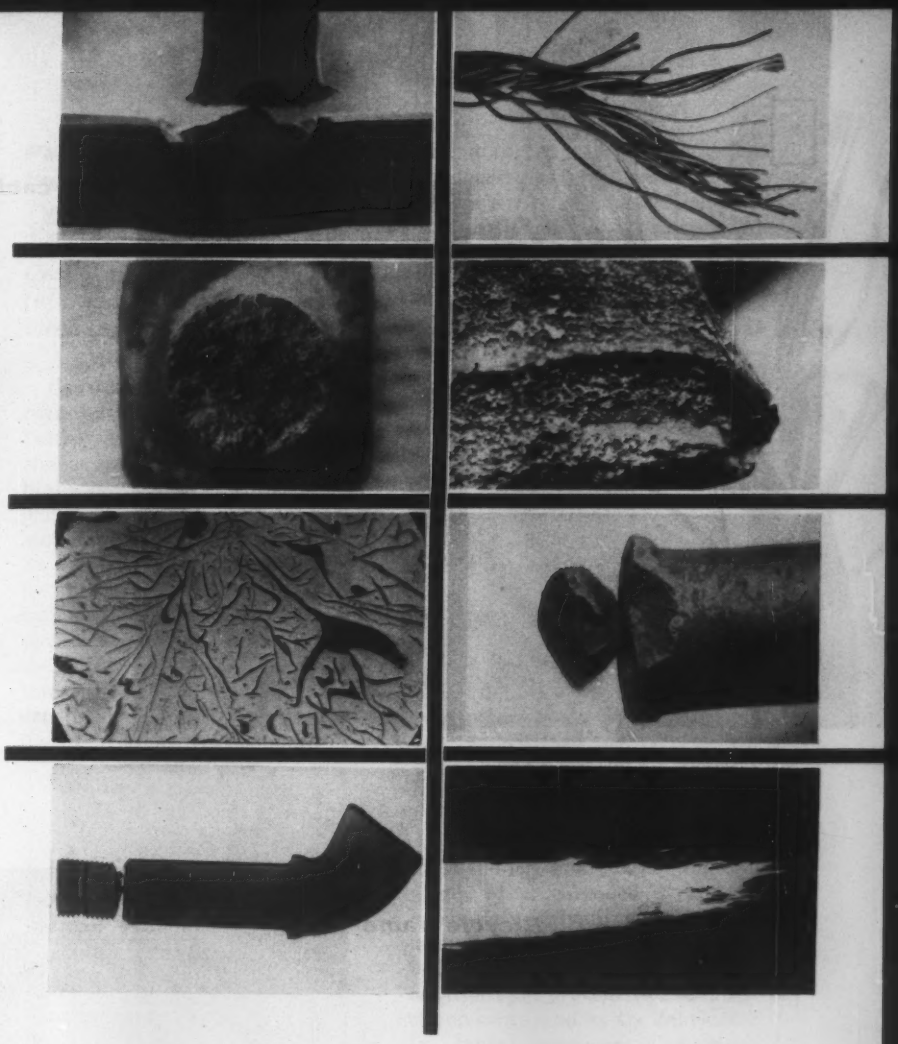
One of the largest electronic companies recently announced a successful experiment with lead-based piezoelectric ceramic sheet stock. By coating the surface with a luminous material, they were able to excite the ceramic electrically and produce visual figures on the surface as in a cathode ray tube. It takes little imagination to visualize the TV picture tube of the future hanging from the wall in a picture frame.

New uses for lead and its many compounds are continually being explored by L.I.A. For technical information and assistance on this and other applications of lead both old and new, outline your areas of special interest in a letter to: Office of Technical Information, Lead Industries Association, 292 Madison Avenue, New York 17, New York. 4479

LOOK AHEAD WITH LEAD

For more information, turn to Reader Service card, circle No. 334

Why Did These Parts Fail?



Laboratory sleuthing shows that improper materials selection and fabrication was responsible for the failure of these eight parts. See the following four pages to find out how you can avoid similar failures.

by John Carroll, *Senior Metallurgist, United States Testing Co.*

■ Improper use of materials is probably the most important single cause of product failure. In many cases it is hard to detect, but a logical process of examination will turn up important clues.

First, along with a visual examination, find out all pertinent facts about the part and its use, particularly service handling and operating stresses. Next, examine the fracture surface under low magnification. At this point you will usually be able to tell if the part failed because of corrosion, overload or fatigue.

Overload usually produces a ductile fracture in which the fracture surfaces have a uniform texture. By placing the broken halves together you can make some estimate of how much deterioration occurred and whether the fracture is brittle or ductile.

Fatigue results from gradual propagation of a crack in a load-bearing part that is cyclically stressed. In fatigue failures the fracture surface exhibits two distinct zones: 1) The smooth area frequently bears marks resembling the outside of a clamshell; these define the outlines of the original microscopic crack when it propagates through the structure. 2) The rougher surface is an area of sudden failure that occurred after the part was weakened by encroaching cracks.

You can usually detect these signs in the early stages of an investigation. If you need more detailed information, the material should be then examined in the laboratory to find:

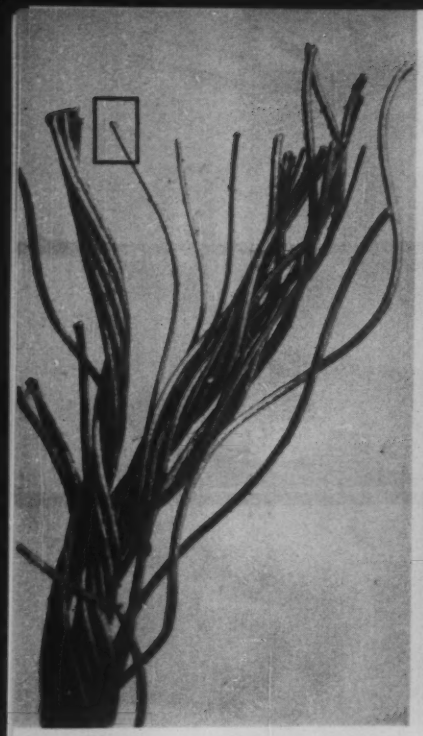
1. Chemical composition. Was the part made from specified materials? If no specification was given, was the material adequate for the application?

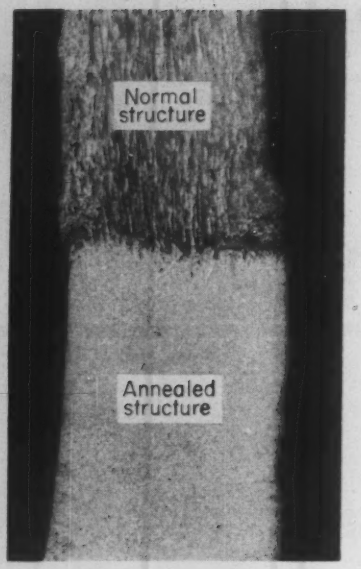
2. Mechanical properties. Compare tensile and yield strengths, elongation, impact resistance, hardness, toughness and ductility with specifications for the part or with known properties of the material in good conditions.

3. Microscopic properties. Using a microscope, a trained observer can characterize and evaluate constituents of the material. Thus, it is possible to detect structural flaws such as nonmetallic inclusions, microcracks, heat treatment deficiencies, and porosity.

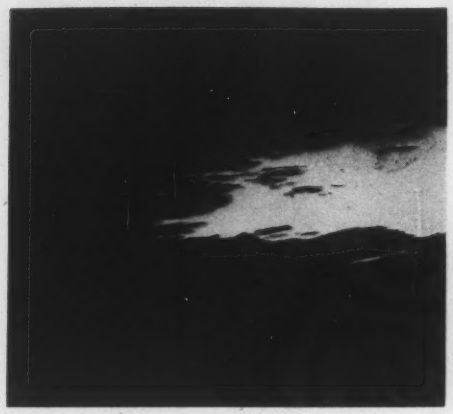
Though the metallurgist can find the cause of failure after it happens it is much more satisfying for him to use his talents in preventing failure right from the start. With all of the knowledge at hand today, you can prevent almost all metal failures, regardless of their cause, if you take adequate precautions from the initial design stages right through fabrication and assembly.

Turn page for case histories



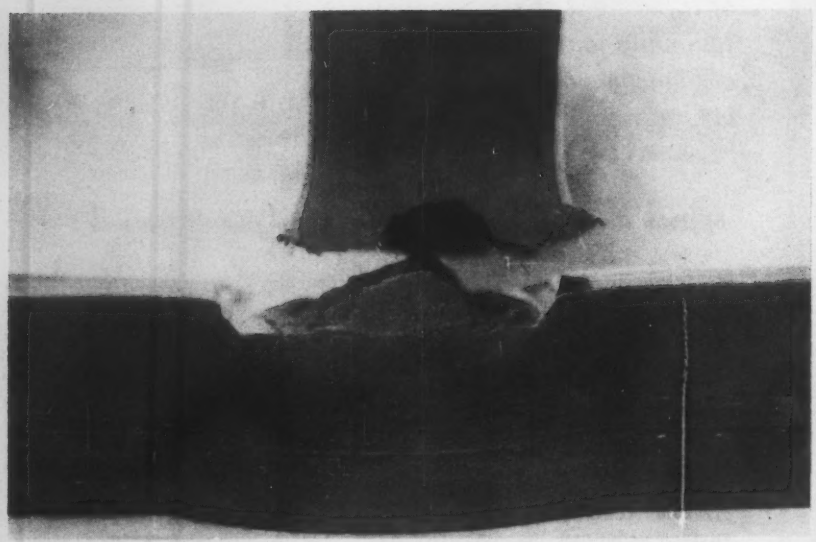


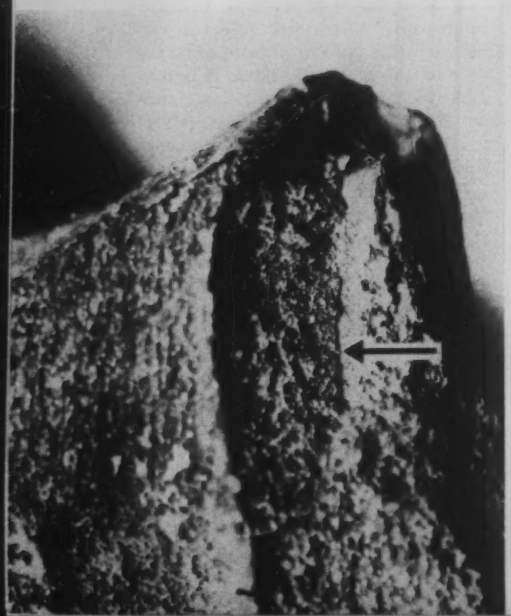
Wire cable



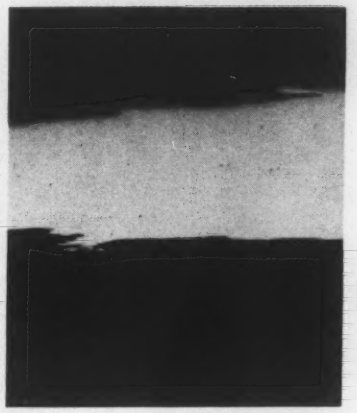
Wire rope

Bicycle frame





Automobile trailer box frame



Part: Bicycle frame

Type of failure:
Broken frame joint

Cause of failure:
Faulty welding technique

Weld failures are not uncommon and can have unfortunate consequences. Shown at the left is a welded frame member of a child's bicycle which broke away, injuring the rider.

Laboratory tests showed that the two elements making up the joint were inadequately fused together and that a crack had existed in the structure for some time. As the cross section of the reconstituted joint indicates, there was inadequate and improper fusion, probably due to lack of heat during welding.

Part: Automobile trailer box frame

Type of failure:
Fracture

Cause of failure:
Internal defects and structural weakness

Considerable property damage resulted when the automobile trailer steel box frame member shown at the left fractured on the highway. Visual examination under low magnification revealed numerous internal fissures (shown by arrow) that were presumed to be in the member when it was manufactured. Further microscopic sectioning revealed that these discontinuous zones persisted throughout the member and drastically reduced the loadbearing capacity of the member.

Part: Wire cable

Type of failure:
Ruptured strands

Cause of failure:
Mishandling

The wire cable shown in the two photographs was used to support part of a portable drilling rig. This cable snapped in service and the collapse of the rig caused the operator to be injured.

In order to determine the cause of failure, critical areas of the rope were given a rigorous metallurgical examination. This examination revealed that the fracture was a ductile failure, common in wire cable when it is overloaded. However, it also revealed that certain wires adjacent to the fracture (circled area) appeared to be fused together. As the photomicrograph shows, there is a distinct change in the structure of the metal adjacent to the point of failure. This proved to be an important discovery because it indicated to investigators that failure was due to more than just overload.

Subsequent examination at the site disclosed that the cable had inadvertently been contacted by a welder's torch. This had annealed and softened the normal hard-drawn wire structure and reduced tensile strength to a point where it could no longer support the load. As the photomicrograph shows, the normal hard-drawn wire structure ends abruptly and changes to a soft, spherodized annealed structure which, although not abnormal, is definitely unsuitable for wire cable.

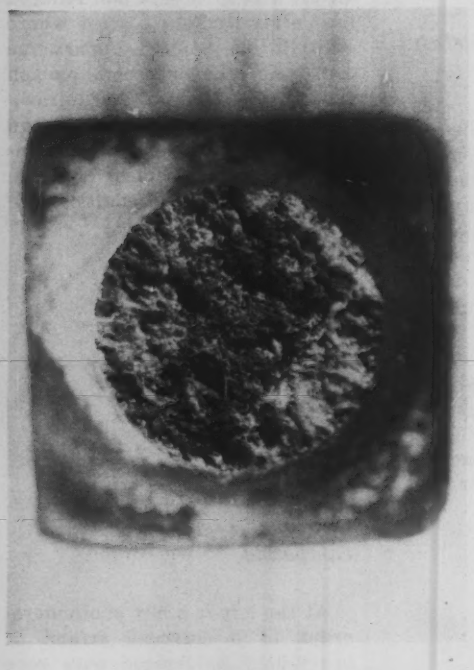
Part: Wire rope

Type of failure:
Corrosion

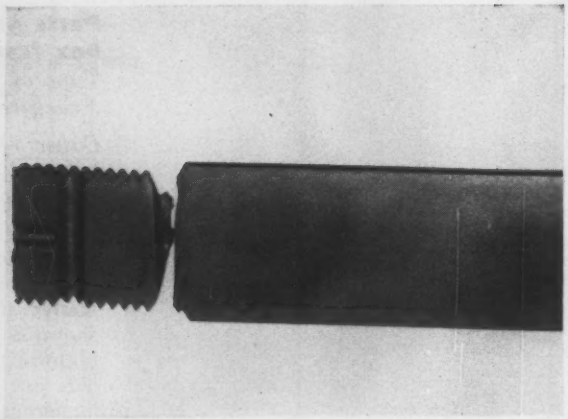
Cause of failure:
Improper rust preventive compound

At the left is a 50x photomicrograph of a corroded strand of heavy-duty galvanized wire rope used in marine hauling. The rope is normally treated with a combination rust preventive and lubrication compound by the fabricator to prevent corrosion. The previously used compound worked fine; however, after changing compound suppliers the rope fabricator started to receive complaints from the field that the rope was unsuitable for use in marine atmospheres.

Subsequent examination of the ropes showed that failure was caused by corrosion and that the zinc layer was substantially depleted at the area of failure. No abnormalities were detected in the composition and structure of the rope as manufactured. However, analysis of the rust preventive compound disclosed that it contained certain metallic constituents that caused excessive corrosion under salt spray conditions. Observations showed that the metallic constituents in the compound, when in the presence of salt water, reacted with the zinc coating on the wire, thus rapidly exposing the base steel to attack.



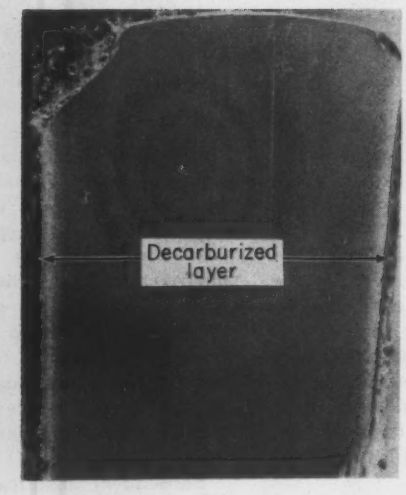
Marine stanchion

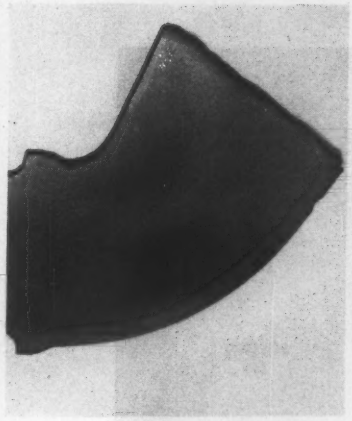


Crane hook

Cast iron
compressor head

Geologist's
hammer





Part: Marine stanchion

Type of failure:
Fracture

Cause of failure:
Improper structure due to faulty casting practice

In many cases visual examination alone is sufficient to determine the cause of failure. This was so with a cast brass stanchion which was part of a rigging assembly on an ocean-going vessel. The stanchion failed in service and caused a considerable part of the superstructure to collapse.

One end of the fractured part (see photo) was delivered to the laboratory with the stipulation that no tests destructive to the part would be allowed. A visual examination was sufficient to pinpoint the cause of failure. The "Chinese writing" pattern on the fractured face indicated that the stanchion was improperly cast. This pattern is what happens when metal transforms from liquid to solid at an improper rate. Shrinkage occurs and certain alloy constituents separate out at the grain boundaries with a consequent lack of cohesion between the metal grains.

Part: Geologist's hammer

Type of failure:
Chipping of face

Cause of failure:
Soft structure due to faulty heat treatment

Even a prosaic item such as a hammer can be dangerous if it is improperly made. The chipping hammer at the left figured in the case of a geologist prospecting in Newfoundland who was struck in the face by a fragment of the hammer's striking face.

Preliminary examination showed that the fracture had a brittle appearance and that the side of the hammer was considerably softer than the face itself (Rockwell C35 vs C55). An enlarged view (see photo) of the section through the defect showed that a layer of soft decarburized metal (the light colored rim) was present over the entire working surface. This layer was produced when carbon burned from the steel during heat treatment, leaving the metal soft and weak. Normally, the decarburized layer on a heat treated part is machined off. However, this was not done on the hammer and the decarburized layer presented a zone of weakness.

Part: Cast iron compressor head

Type of failure:
Bursting

Cause of failure:
Defective structure

This case involves a refrigerator that was installed in a cold storage warehouse. According to eyewitness accounts, a hissing sound was heard when test pressure was applied to the system. The foreman directed a workman to determine the source of the leak. While he was doing so, a large cast iron component exploded and killed him.

Subsequent investigation showed that the basic iron was seriously defective. Tensile tests conducted on bars machined from fragments of the part showed that tensile strength was only 11-12,000 psi instead of the minimum 20,000 psi required by ASTM for lowest grade gray iron.

Furthermore, metallographic study of the section adjacent to the fracture showed that the structure contained graphite flakes of a size greater than standard (see 100x photomicrograph at left). The excessive number and size of the flakes are characteristics of abnormally weak cast iron and can cause serious deficiencies in the strength of the metal.

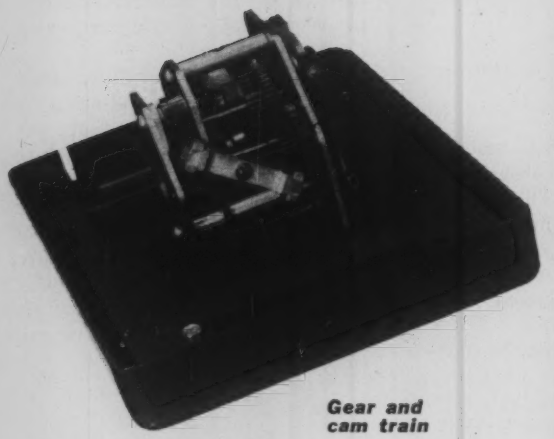
Part: Crane hook

Type of failure:
Fatigue fracture

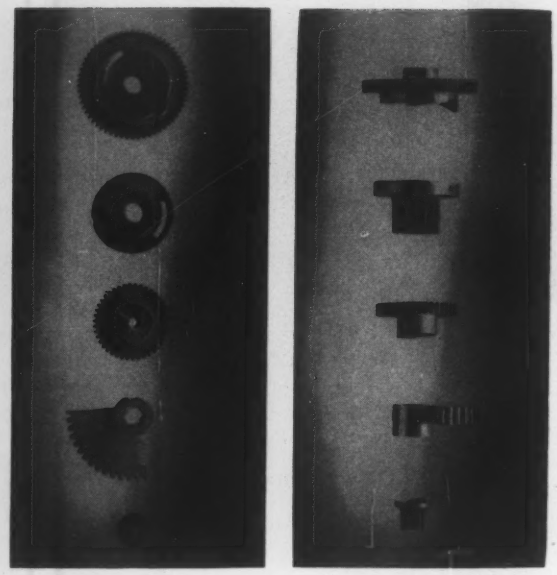
Cause of failure:
Inadequate load bearing area

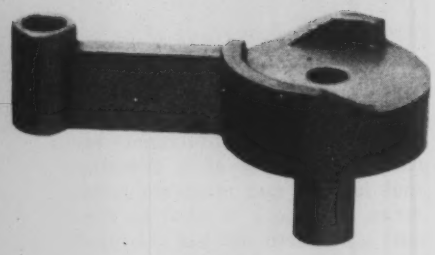
Crane hooks like the one at the left figured in an unfortunate series of accidents at a company that handles and processes metal scrap. The hook is used to support a magnetic lift head on yard cranes and always failed at about the same spot after relatively short periods of use. The fracture occurred across the shank of the hook at the thread roots. Yard personnel advanced the theory (somewhat startling to a metallurgist) that the magnetic force in the head was causing realignment and weakening of the metal grains of the hook.

The actual cause of failure was not nearly so exotic. Due to improper metal allowance a substantial portion of the hook shank was cut away by threading. This reduced the effective load bearing area by about 30%. Furthermore, bending stresses on the hook were greatest at the root of the last thread (not usually fully enclosed by the socket). Fatigue cracks originated at this root and propagated through the structure to such an extent that it could no longer support service loads and thus ruptured suddenly.



Gear and cam train



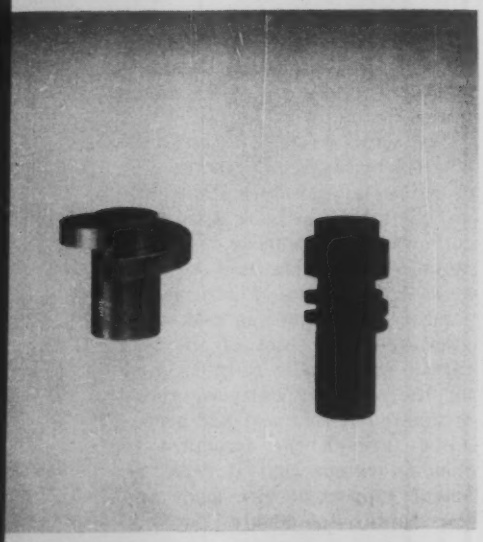


Phonograp motor toggle link

Three Prize Winning Metal Powder Parts

These metal powder parts are three winners in New Jersey Zinc Co.'s Nonferrous Metal Powder Part of the Year competition. Another was described in June, p 12.

Distributor cam



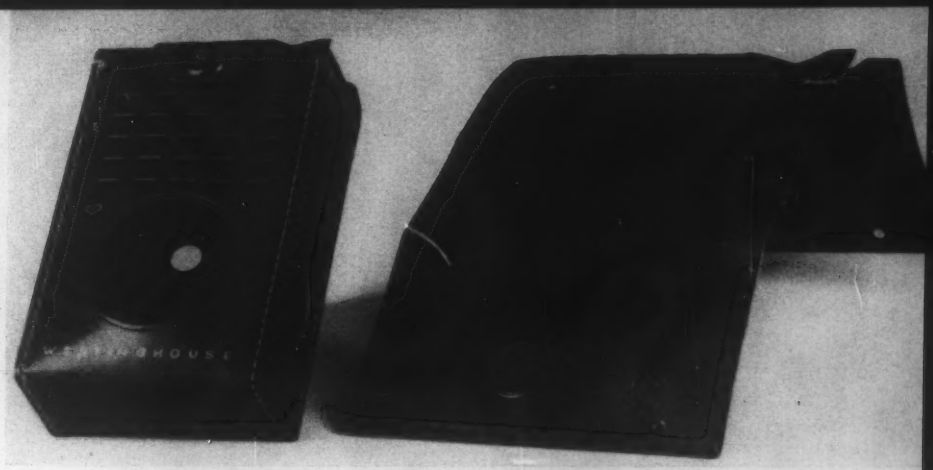
Gear and cam train formed from brass powder is used in the fire alarm pull box shown above. It would be extremely difficult to produce the five parts of the assembly by conventional cutting methods, and virtually impossible to hold the tolerances to the required ±0.002 in.

Combining the gear and cam functions simplifies assembly and cuts costs. The train is tough, self-lubricating, noncorrosive and extremely reliable. (Grand Prize: S. H. Couch Co. and Engineered Plastics, Inc.)

Phonograph motor toggle link pressed from brass powder must have circular and parallel bearing holes accurate to ±0.00025 in. Powder metallurgy is the only economical way to make the intricate shape with the necessary precision. Brass powder was selected for its structural strength and low friction.

The link combines two functions: 1) it provides a free floating suspension for the drive disk on the motor; and 2) its cams shift the turntable idler wheel against a stepped pulley on the motor shaft to change turntable speed. (Award of Distinction: General Industries Co. and American Powdered Metals, Inc.)

Distributor cam for bowling Pinspotters is produced from oil-impregnated, prealloyed bronze. Cost was cut 90%, and sliding characteristics necessary to prevent galling and binding were improved by substituting the powdered part for its machined steel counterpart. (Award of Distinction: American Machine & Foundry Co. and International Powder Metallurgy Co., Inc.)



Decorative durability *at costs as much as 50% lower than that of leather makes vinyl-coated saturated cellulose an ideal material for carrying cases.*

Cut Your Costs with . . .

Bonded Fibrous Sheets

Saturated cellulosics offer an infinite variety of physical properties and surface characteristics.

by Dr. Allen S. Powell, *Vice President, Research and Development, Texon, Inc.*

■ Saturated cellulosics are versatile in both performance and fabrication. Properties that can be altered to meet specifications include: 1) mechanical properties such as tensile and tear strength, and stiffness 2) surface characteristics, such as color, texture and abrasion resistance, and 3) physical properties, such as density, porosity and resistance to chemicals, moisture and fungi.

The materials, ranging from 0.015 to ⅛ in. in thickness, can be formed by molding, die cutting, laminating or drape forming. They can be assembled by glueing, stitching, riveting or mechanical fastening. They can be printed, embossed, or coated.

Capping this versatility is the inherent low cost of the papermaking type of process by which they are made.

Essentially, the materials consist of cellulose fibers which are refined, saturated with binders, and reconstructed to form sheet materials. A variety of *flexible or rigid* binders can be used; different natural or synthetic fibers can be added; various organic coatings can be applied.

Where they're used

A number of well developed commercial applications indicate the design potential of these materials.

Leather simulation — Materials cost reductions of as much as 50% can be obtained by using vinyl-coated saturated cellulose instead of leather for carrying cases, brief cases and overnight bags. Further economies often result from the stable price of cellulose and the controlled dimension of sheets. A variety of finishes can be incorporated in excellent detail.

Gaskets—Latex-saturated cellulose provides a low cost gasketing material for such uses as auto transmission, anti-squeak and taillight gaskets; also, for enclosure gaskets to exclude water or oil.

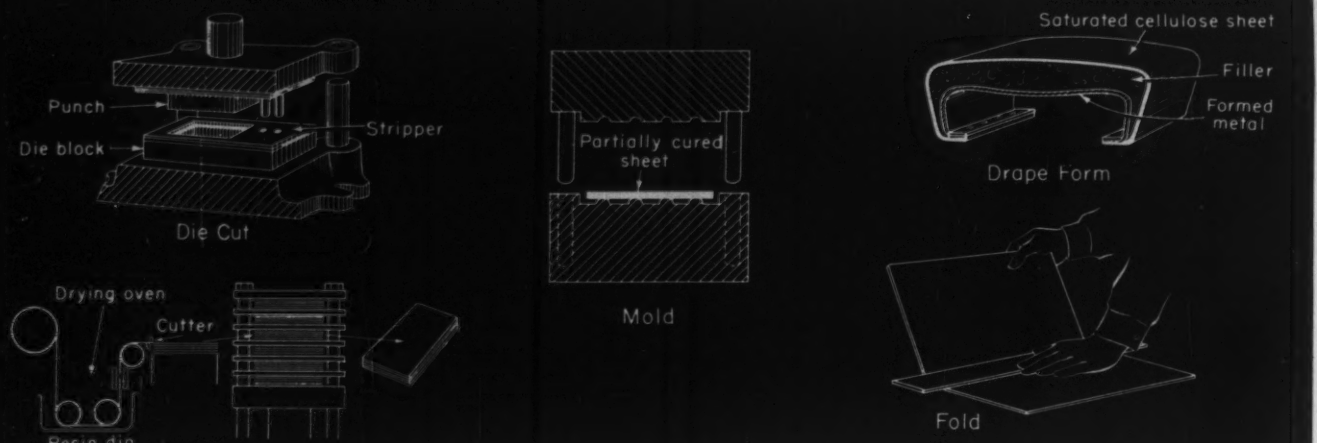
Specific latexes can be selected to provide resistance to fuels, oils and moisture, and to provide a high degree of resilience. Sheets are available in thicknesses of 0.015-0.115 in. with saturant content ranging from 5 to 40% by weight. Dimensional stability is good and consistent sheet size promotes efficient materials utilization.

Battery separators — Longer service life at lower cost than either wood or rubber is provided by phenolic-impregnated cellulose separators for auto storage batteries. Ribs for spacing the plates are molded in, and dimensions and properties are uniform throughout the sheet.

The phenolic-saturated cellulose combines the required acid resistance with the porous structure necessary to permit ionic transfer between positive and negative plates of the battery.

Footwear—Latex-saturated cellulosics provide controlled density and porosity for proper breathing action, as well as resistance to abrasion and moisture required in shoe innersoles. The materials are less costly than leather, and the regularity of sheet size results in more efficient utilization of the material than is possible with irregularly shaped hides.

continued on next page



Ways to Form Saturated Cellulosics

How properties are controlled

Table 1 gives characteristics of several of the most widely used types and Table 2 lists typical properties of two types in various thicknesses. These types were selected only to indicate the general ranges of properties obtainable. Wide variations are producible.

In general, the following variables can be altered to control properties of the final sheet:

1. *Pulps*—Highly refined alpha cellulose grade pulp permits higher saturant content than lower grades, and usually produces higher physical properties.

Blends of different cellulose pulps, as well as blends of cellulose with synthetic fibers, such as polyester, acrylic or rayon, can be used to control specific properties. For example, acrylic fibers provide high tensile strength; thus even small amounts of acrylic fiber blended into a cellulose pulp provide noticeable increases in strength of the sheet.

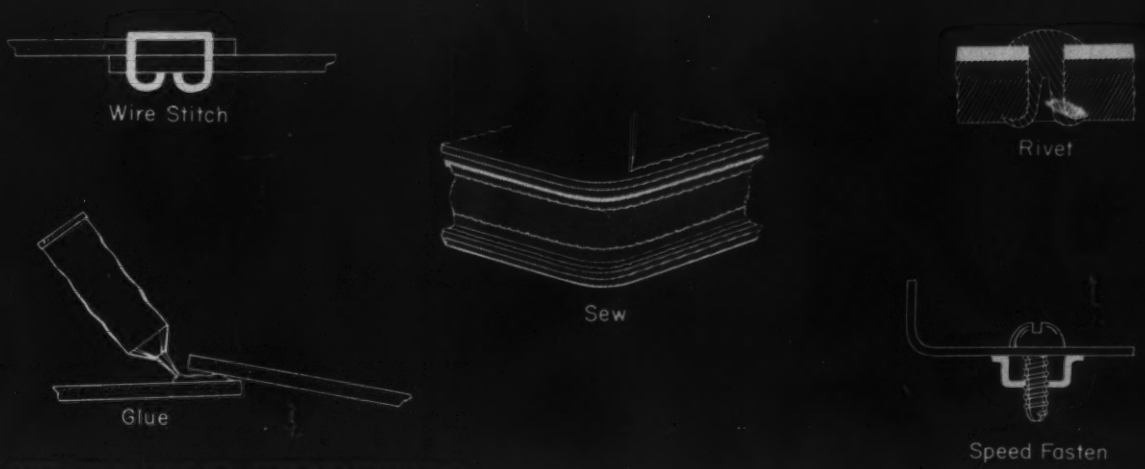
2. *Saturants*—In general, a natural or synthetic latex provides flexibility, whereas phenolics provide hardness and rigidity. Blends of saturants produce intermediate degrees of stiffness and other properties. Amount of saturant used not only affects stiffness but can also be varied to control porosity.

3. *Additives*—Chemical additives provide a further means of control. Typical additives include antioxidants for latex saturants, heat sensitive materials to promote thermoplasticity, acid acceptors to absorb free acids in the saturant, and dispersing and penetrating agents to promote saturation and impregnation of fibers.

4. *Surface coatings*—A precoating operation improves appearance and abrasion resistance by

TABLE 1—CHARACTERISTICS OF TYPICAL SATURATED CELLULOSE MATERIALS

Type ↓	Characteristics	Suggested Applications
Pure alpha cellulose fiber saturated with natural and/or synthetic latex	Soft, flexible, with built-in breathing action and controlled porosity. Mildew resistant, will not discolor. Relatively tough and resistant to abrasion	Shoe and other footwear components
Pure alpha cellulose saturated with latex and acrylic resin	Greater stiffness than latex saturated material. Good resistance to heat, moisture, steam. Can be boiled	Underlay for vinyl tile, backing material for clothing and other products. Replacement for medium-grade felts
Dense cellulose fibers saturated with latex	Relatively soft, flexible, resilient with good mechanical properties. Fuel, oil, water resistant. Can be readily cut and formed. Good tear strength	Gaskets for automotive, electronic, similar types of equipment
Cellulose fiber saturated with latex and vinyl coated	Very flexible, pliable, with excellent abrasion resistance characteristic of vinyl. Can be glued, stitched or stapled. Available in wide range of colors and patterns. Readily bonded to metals and other nonmetallics. Can be embossed	Leather replacement for luggage, camera and radio cases. Quality containers, boxes, display cases
Wood and cotton cellulose saturated with phenolic	Hard and relatively brittle in thin sheets. Retains porous structure of wet-web saturated cellulose. Good acid resistance. Can be produced in all phenolic colors	Battery separators. Sheets can be partially cured and laminated to form variety of shapes with excellent strength, dense structure
Alpha cellulose fibers saturated with acrylic resin-latex blend and vinyl coated	Soft and pliable, with good edge tear resistance and good strength. Excellent appearance	Replacement for suede and other soft leathers in all types of consumer products
Blended cellulose and synthetic fibers with blended natural and synthetic latexes	Highly resilient, extremely flexible. Good edge tear resistance and abrasion resistance	Backing and cushioning. Replacement for high grade felts
Cellulose fibers saturated with acrylic resin	Heavy, dense, thermoplastic	Shoe and luggage components. Can be used without backing material when needed with leather



Ways to Join Saturated Cellulosics

making fiber ends lay flat. A vinyl coating applied after the precoating further improves abrasion resistance and appearance, as well as chemical resistance.

5. *Fillers*—A variety of fillers can be used to obtain specific property combinations or to reduce costs.

Wet web process controls porosity

Three basic methods are used to produce saturated celluloses: wet web, dry web, and beater saturation. The wet web method is the most widely used, and the materials discussed here are produced by this method.

Wet web process—High alpha cellulose wood pulp is thoroughly dispersed in a water solution and deposited on a Fourdrinier wire screen, which drains off water and agitates the pulp to interlock indivdual fibers. The sheet comes off the wire and is fed into a saturating bath through pressure rolls which squeeze out the remaining water to permit saturation by the binder. The binder thus encases each individual fiber, and in some cases penetrates the structure of the fiber itself.

From the saturant bath, the sheet passes through metering rolls which control saturant content, then through drying cans to set the binder, and through calendering rolls to control final thickness.

The resulting structure consists of interlocked, coated fibers with many interstices, resulting in a characteristic breathing action. A wide range of porosities can be produced and held to close tolerances.

A number of different saturants can be used with the wet web process, i.e., theoretically, any material that can be dissolved, emulsified or dispersed in water. Saturant content can be varied from zero up to about 50% by weight, although the type of fiber used affects the saturant limit.

Sheets produced by wet web processing can vary from about 0.015 to about ⅛ in. in thickness. Widths depend on machine capacity; standard rolls of 100 in. width or more are now available.

Two other processes—The dry web and beater saturation methods are primarily used to produce specialty materials. In the dry web process, the cellulose paper is formed and dried, then immersed in the saturant. Principal advantage is that it is not limited to saturants that can be dissolved or dispersed in water. Principal disadvantage is that distribution and penetration of saturant is limited, especially in heavier gage sheets (thicker than 0.030 in.). The saturant tends to remain concentrated on the surface, rather than dispersed throughout the sheet.

In beater saturation, the saturant is introduced at the beater stage of pulping, prior to production of the sheet. A higher density material can be obtained, but control of density and porosity of the final sheet is limited.

TABLE 2—TYPICAL PROPERTIES

		Type 1[a]			Type 2[b]			
Sheet Thickness, in. →		0.020	0.050	0.080	0.020	0.050	0.080	0.105
	ASTM							
Tensile Strength, lb/in.	D828	36	120	160	74	105	160	260
Stretch, %	D987	12	13	17.5	7.5	10	10.2	12
Edge Tear Strength, lb	[c]	19	65	120	12	44	73	95
Internal Tear Strength (Elmendorf)	D689	480	1300	2100	400	1250	2420	3600
Stiffness, gm-cm	[d]	50	200	1000	70	480	1270	2180
Abrasion, mg loss		—	—	—	400	380	430	360

[a]Blend of alpha cellulose and kraft saturated with latex, 30% by weight.
[b]Pure alpha cellulose saturated with latex, 30% by weight.
[c]TAPPI test method T470. [d]TAPPI test method T451.

U.S. Army photo

Self-propelled 105mm howitzer *typifies new series of ordnance equipment made of lightweight materials. Armor, wheels, ammunition racks and other major parts are made of aluminum; reinforced plastic is used for fuel tanks.*

Lightweight Ordnance Equipment

Changes in military concepts emphasizing speed and mobility have led the Army to take a fresh approach to ordnance equipment design. As a result, light metals, high strength steels, and plastics are being widely used.

by Charles B. Salter, *Detroit Tank Arsenal, Ordnance Tank Automotive Command, and* **Robert J. Fabian,** *Associate Editor, Materials in Design Engineering.*

■ Because of new global policies and the far-reaching effects of nuclear weapons, the Army has made sweeping changes in its approach to manpower, tactics and equipment, particularly ordnance equipment. In the past decade or so a quiet revolution has been taking place in the design and materials used for ordnance equipment. In fact changes have been so radical that an ex-GI of World War II vintage would scarcely recognize much of today's ordnance equipment. Our new ordnance equipment not only looks different but does more, and does it more efficiently than previous designs. For example, today's ordnance equipment must be:

▸ *Air transportable.* Since ordnance equipment may be required at short notice almost anywhere on the globe, it is essential that as much equipment as possible be air transportable. This requirement fixes the weight and size of equipment. In addition, much of the equipment that is air transported must be capable of being parachuted in a combat-ready state. Thus, in addition to being light in weight and small in size the equipment must be able to withstand high shock loads.

▸ *Amphibious.* The necessity for mobility has led to a firm requirement that most of our new ordnance equipment be capable of crossing streams, rivers and lakes under its own power. This requirement puts a premium on materials which, in addition to being lightweight, have high corrosion resistance and lend themselves to leakproof construction.

▸ *More rugged.* Ruggedness has always been a prime requirement for ordnance equipment but has become even more important in recent years because of tougher environments. In addition to being capable of traversing all types of terrain, today's equipment must be able to withstand tough environments from extreme arctic cold to hot desert conditions.

Designers have always recognized the importance of using lightweight materials but until recently were held back because many strategic materials such as aluminum, magnesium and tita-

nium were committed to aircraft and missiles. However, our production capacity for these metals is now so great that we can supply enough to meet all military requirements. Thus, starting about the time of the Korean war, designers of the Ordnance Tank Automotive Command (which includes the Detroit Tank Arsenal) got the go-ahead to use more lightweight materials.

Actually, weight reduction is not just a matter of using lightweight materials but also involves closer attention to design. Thus, in redesigning equipment engineers have taken advantage of latest engineering developments to make equipment more efficient and reduce its size. In order to do this they have re-evaluated their concept of required safety factors and have kept a sharp eye out to prevent overdesign.

As in aircraft design, an important advantage of reducing the weight of a component is that it often sets off a chain reaction that permits weight reduction in other components. For example, if we can make the hull of a vehicle lighter, then we can carry it on a lighter suspension which is propelled by a smaller engine which requires a smaller power train.

Naturally, the lightweight metals may require some beefing up to compensate for their lower strength. However, the extra metal required is often surprisingly low. For example, lightweight vehicle wheels have been made in sizes comparable to steel wheels by using gusseting and other stiffening devices. Furthermore, as already noted, the lightweight components themselves frequently enable engineers to redesign associated parts so that they are much smaller and lighter, thereby reducing the loads that the lightweight components have to withstand.

***Aluminum** is becoming a dominant structural material for ordnance equipment because of its high strength-to-weight ratio, ballistic properties, and corrosion resistance.*

A large measure of the success of lightweight ordnance equipment depends on the use of aluminum alloys, particularly the newer high strength weldable alloys of the 5000 series (see "New 5XXX Aluminum has enabled weight Weldable," M/DE, July '59, p 91). The suitability of these alloys for ordnance equipment stems from their:

▸ *Low weight and high strength.* Aluminum has enabled weight savings of up to 50% in some vehicles. In armor plate applications the weight savings are less, but still important.

▸ *Good ballistic properties.* When suitably processed, the high strength weldable alloys such as 5083 and 5456 often provide better ballistic protection than an equal weight of steel.

▸ *High corrosion resistance.* This is a very important requirement for ordnance equipment. Needless to say, aluminum's well-known corrosion resistance has been an important selection factor. The metal requires little or no protective coating. When it is painted, scratches or minor damage do not require immediate repair since the metal does not readily corrode.

▸ *Competitive cost.* Despite its higher initial cost, aluminum can, in the long run, be cheaper to use than competitive metals. In some cases aluminum has proved less expensive to fabricate and join than other metals. More important, however, is the fact that every pound saved by using aluminum in a vehicle can be translated into greater range and fuel economy, higher payloads, less tire wear and lighter suspensions. Thus, by using lightweight metals, the "real cost" of the vehicle can be substantially reduced.

The percentage of aluminum being used in some ordnance vehicles is amazingly high, and often approaches that used for aircraft and missiles. The T-195 self-propelled 105mm howitzer, for example, uses 14,000 lb of aluminum, and the LARC-5 amphibious cargo vehicle will use over 7000 lb. Large amounts of aluminum are also being used in tanks, notably the M-60 which uses over 6000 lb for such components as wheels and hubs, fenders, ammunition containers, air cleaners, racks and fittings, engine parts, transmission housing and two 200-gal fuel tanks.

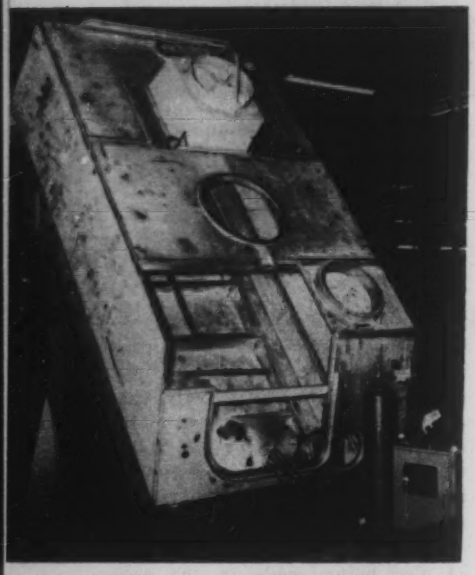
The Army is also testing a new series of 3½-ton (XM-434 series) and 5-ton (XM-453 series) trucks which make widespread use of aluminum for the cargo body, cab and many other components. In contrast to the previous M-41 which has a curb weight of 19,200 lb, the new XM-453 will weigh in at only 12,000 lb.

Widespread use of aluminum is also being made in the new XM-410 2½-ton General Purpose Cargo Truck. Despite its 2½-ton capacity this truck will weigh only 8600 lb, about half the weight of the Army's present standard 2½-ton truck. Its light weight largely results from the use of about 2000 lb of aluminum for the wheels, hubs, body, frame rails, cab, fuel tanks, suspension components, and transmission axle and motor housings. The aluminum wheels, for example, weigh only 26 lb apiece, as compared to 56 lb for steel wheels. Since the vehicle has nine wheels (including the spare), the total weight savings achieved by switching to aluminum is 270 lb. This in turn enables associated components to be smaller and lighter.

A complete rundown on these and other applications is given in the case histories, pp 104-6.

***Magnesium** too, is being used in increasing quantities, although not nearly as much as aluminum. It is ideal where extreme lightweight is needed and where its strength is adequate for the use.*

Compared to the other lightweight metals and steel, magnesium, as the accompanying table shows, has the lowest weight and highest stiffness for its weight. Because of these advantages it has been intensively developed for ordnance equipment and there are many successful applications. Magnesium castings are widely used for all types of casings, and forgings are proving particularly valuable for wheels, notably for the M-274 Mechanical Mule and the new M-151 ¼-ton utility vehicle. Extrusions and sheet are also quite popular, notably for platforms (Mechanical Mule) and cargo floor pans; the latter are sometimes coated with plastisol.



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The relatively new magnesium-lithium alloys look particularly promising for ordnance equipment, and a 14 lithium–2% aluminum alloy is now receiving intensive development for future applications. This alloy has a stable structure in the beta range and has the body-centered crystallographic structure of lithium rather than the hexagonal-close-packed structure of magnesium. This is an important advantage because it can be cold worked more easily than conventional magnesium alloys and can thus be provided with high strength and good armor properties. The alloy weighs one-half as much as aluminum and is probably the lightest structural alloy now available.

The Army is investigating the possibility of constructing entire vehicles from the 14 lithium–2% aluminum alloy in an effort to achieve maximum weight reduction without sacrificing ballistic protection. A magnesium-lithium version of the M-113 armored personnel carrier (Fig 1), now being made by Food Machinery & Chemical Corp., is being run on the same production line as the aluminum version.

In common with other magnesium alloys, the magnesium-lithium alloy needs careful surface protection to prevent corrosion. Army engineers have found that by close process control they can improve the corrosion resistance of magnesium-lithium alloys so that it almost becomes equal to that of conventional magnesium.

However, since a surface coating is required, Army engineers have worked closely with Dow Metal Products Co. to develop a better protective coating for magnesium-lithium alloys. Notable success has been achieved with a new stannate (tin) coating applied from a bath of 6% potassium stannate and 10% tetrasodium pyrophosphate. This coating is claimed to be the best protective coating yet developed for magnesium. In addition to providing high corrosion resistance it serves as an excellent paint base and does not affect fatigue properties. For these reasons it will be used to protect the entire magnesium-lithium hull of the M-113 armored personnel carrier.

***Titanium** offers many desirable properties for ordnance equipment and is undergoing intensive investigation in experimental applications. Although it has a bright future, it is currently limited by relatively high cost and fabrication problems.*

Titanium is a "natural" material for lightweight ordnance equipment because of its high strength-to-weight ratio. Because of its high strength, titanium can often substitute for steel parts, section-for-section, without any increase in dimensions. In such cases it results in weight savings of 25 to 40%.

Ordnance engineers have been alert to titanium's possibilities ever since it became available in experimental quantities. However, although the metal appears to have an excellent future it is still limited to experimental applications because of its relatively high cost and some fabrication problems. Nevertheless, it is only a question of time before it comes into its own.

Ordnance engineers are still having some problems with welding and machining titanium, although these problems are not nearly as serious as they used to be. Welding problems are rapidly disappearing as a result of welding studies at various Army in-

porosity.

3. *Additives*—Chemical additives provide a further means of control. Typical additives include antioxidants for latex saturants,

natural and synthetic latexes	sistance	
Cellulose fibers saturated with acrylic resin	Heavy, dense, thermoplastic	Shoe and luggage components. Can be used without backing material when needed with leather

stallations. For example, over five years ago Ordnance Tank Automotive Command conducted a program in which an armored cab was welded of titanium armor (see Fig 2). This cab successfully withstood ballistic shock attack even though made of a titanium alloy containing 7% manganese which is not considered as weldable as the currently used alloy containing 6% aluminum and 4% vanadium.

As an indication of titanium's promise, ordnance engineers currently have a program calling for the manufacture and test of new and improved titanium armor plate, vehicle cupolas, escape hatches and torsion bars. Tests are also underway to evaluate entire track suspension systems, including forged road wheel arms, wheels and track shoes.

Most of the experimental work on titanium has been with forged and other wrought parts. Some experimental work has been done with castings. However, at present they do not look too promising for ordnance parts because of their limited size and the limitations imposed by the controlled atmosphere required in casting.

2—Experimental armored cab *of titanium for Ontos vehicle has successfully withstood ballistic tests.*

New high strength steels *are enabling designers to cut section size and make important weight reductions.*

Standard medium carbon and alloy steels have long been the workhorse materials for ordnance equipment. However, with today's accent on lightweight ordnance, engineers have been quick to recognize the value of the newer low carbon, higher yield strength steels. These steels are now being used in considerable quantities, notably for heavy duty trailer chassis to reduce weight and increase durability.

Important use of higher yield strength steel has also been made in the M-151 MUTT (military utility tactical truck). The MUTT body is made by single-unit welded construction to eliminate the frame. Engineers have cut weight by over 130 lb and provided a more rigid body.

The new ultra high strength and vacuum melted steels are also being investigated for highly stressed parts such as torsion bars and road wheel arms. Parts made from these materials will soon be tested to see if they last longer and provide lower weight than conventional materials.

New manufacturing techniques such as precision casting are also being investigated to reduce the cost of forged parts. Precision cast sprockets, end connectors, gun muzzle brakes, and crankshafts have been made for various vehicles. In addition to being cheaper (because it reduces machining time), precision casting also conserves a great deal of critical metal because the metal is used more efficiently.

Plastics *have much to offer in the way of toughness, high strength, low weight and good optical properties. They are currently being used in many significant applications and will play an important role in future equipment.*

The wide range of plastics used for ordnance equipment should end all doubts about the ruggedness and durability of these versatile materials. Ordnance engineers have been quick to exploit the advantages of plastics and have demonstrated that, when properly engineered, they can be ideal substitutes for heavier metal parts. In addition to light weight, plastics are proving popular because of their high strength, lack of corrosion, optical properties, and their ability to be compounded in various colors so as to eliminate painting.

Glass-reinforced plastics are demonstrating good potential for cabs, wheels and armor. After being successfully used as a body armor material, glass-reinforced polyester (Doron) is now being tried for vehicles such as ambulance bodies (Fig 3) whose weight limitations preclude use of conventional body armor. Tests show that the plastics body provides fragment protection never before obtainable in a thin steel cab.

Aside from armor, reinforced plastics have demonstrated their suitability for a number of other applications, notably fuel tanks. Reinforced plastics (as well as aluminum) can also be used for large ordnance gasoline and water supply tanks.

In their quest for lower weight, ordnance engineers are now specifying reinforced plastics for ammunition racks, storage boxes and vehicle seats. These materials have also been receiving much attention for wheels as a light-

many interstices, resulting in a characteristic breathing action. A wide range of porosities can be produced and held to close tolerances.

Internal Tear Strength (Elmendorf)	D689	480	1300	2100	400	12[illegible]	[illegible]	[illegible]
Stiffness, gm-cm	d	50	200	1000	70	480	1270	2180
Abrasion, mg loss		—	—	—	400	380	430	360

[a]Blend of alpha cellulose and kraft saturated with latex, 30% by weight.
[b]Pure alpha cellulose saturated with latex, 30% by weight.
[c]TAPPI test method T470. [d]TAPPI test method T451.

U.S. Army photo

Self-propelled 105mm howitzer *typifies new series of ordnance equipment made of lightweight materials. Armor, wheels, ammunition racks and other major parts are made of aluminum; reinforced plastic is used for fuel tanks.*

Lightweight Ordnance Equipment

Changes in military concepts emphasizing speed and mobility have led the Army to take a fresh approach to ordnance equipment design. As a result, light metals, high strength steels, and plastics are being widely used.

by Charles B. Salter, *Detroit Tank Arsenal, Ordnance Tank Automotive Command, and* **Robert J. Fabian,** *Associate Editor, Materials in Design Engineering.*

■ Because of new global policies and the far-reaching effects of nuclear weapons, the Army has made sweeping changes in its approach to manpower, tactics and equipment, particularly ordnance equipment. In the past decade or so a quiet revolution has been taking place in the design and materials used for ordnance equipment. In fact changes have been so radical that an ex-GI of World War II vintage would scarcely recognize much of today's ordnance equipment. Our new ordnance equipment not only looks different but does more, and does it more efficiently than previous designs. For example, today's ordnance equipment must be:

▸ *Air transportable.* Since ordnance equipment may be required at short notice almost anywhere on the globe, it is essential that as much equipment as possible be air transportable. This requirement fixes the weight and size of equipment. In addition, much of the equipment that is air transported must be capable of being parachuted in a combat-ready state. Thus, in addition to being light in weight and small in size the equipment must be able to withstand high shock loads.

▸ *Amphibious.* The necessity for mobility has led to a firm requirement that most of our new ordnance equipment be capable of crossing streams, rivers and lakes under its own power. This requirement puts a premium on materials which, in addition to being lightweight, have high corrosion resistance and lend themselves to leakproof construction.

▸ *More rugged.* Ruggedness has always been a prime requirement for ordnance equipment but has become even more important in recent years because of tougher environments. In addition to being capable of traversing all types of terrain, today's equipment must be able to withstand tough environments from extreme arctic cold to hot desert conditions.

Designers have always recognized the importance of using lightweight materials but until recently were held back because many strategic materials such as aluminum, magnesium and tita-

nium were committed to aircraft and missiles. However, our production capacity for these metals is now so great that we can supply enough to meet all military requirements. Thus, starting about the time of the Korean war, designers of the Ordnance Tank Automotive Command (which includes the Detroit Tank Arsenal) got the go-ahead to use more lightweight materials.

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Naturally, the lightweight metals may require some beefing up to compensate for their lower strength. However, the extra metal required is often surprisingly low. For example, lightweight vehicle wheels have been made in sizes comparable to steel wheels by using gusseting and other stiffening devices. Furthermore, as already noted, the lightweight components themselves frequently enable engineers to redesign associated parts so that they are much smaller and lighter, thereby reducing the loads that the lightweight components have to withstand.

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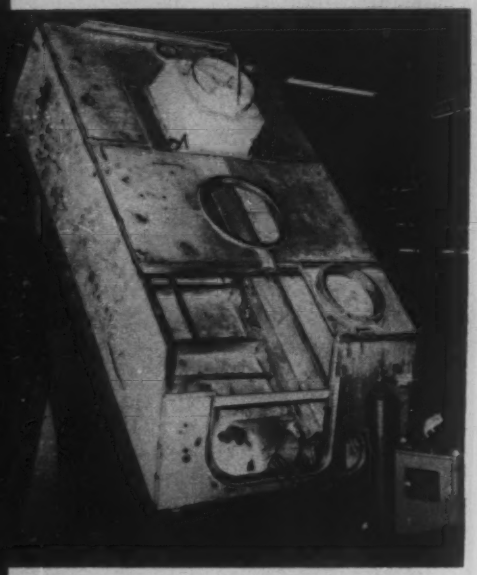

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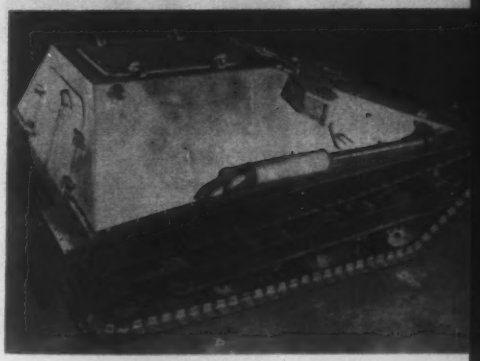

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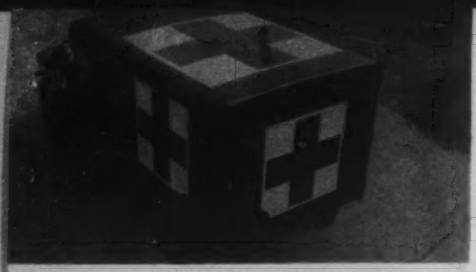


3—Reinforced plastics body *gives ambulance better protection against fragments than equivalent steel body.*

weight replacement for metal, and experimental glass-reinforced polyester road wheels for tanks have been made. However, it is still too early to say if they will eventually go into production.

In addition to the reinforced materials, many other plastics are now being used or are contemplated for use for ordnance equipment. Phenolic sleeve bearings are proving to be a good replacement for metal for large sleeve bearings. Similarly, nylon has replaced metal for some brake bearings. Because of its excellent corrosion resistance and impact properties, nylon has also been selected for the propellers of amphibious vehicles.

Light Metals Promote Transportability and Maneuverability of New Ordnance Equipment

Mechanical Mule weighs only 925 lb

An outstanding example of the use of lightweight metals is the light weapons infantry carrier M-274, commonly called the Mechanical Mule. This vehicle only weighs 925 lb, yet it can carry a ½-ton payload over adverse terrain to front lines.

The extreme lightness of the vehicle largely stems from the use of a flat one-piece magnesium (AZ31B) platform made up of welded extrusions in conjunction with four forged magnesium wheels. The use of lightweight materials plus new design concepts gives the vehicle a 5-hr cruising range and a speed from 1 to 25 mph. It has great versatility and can be delivered by cargo aircraft or by helicopter by means of hooks at each wheel bracket.

M-274 Mechanical Mule U. S. Army photo

¾-ton utility vehicle weighs 400 lb less than previous jeep

U. S. Army photo

¾-ton utility vehicle

The well known jeep of World War II and Korea fame has been drastically redesigned to reduce weight and increase mobility and performance. The new M-151 military utility tactical truck (sometimes called MUTT) is 400 lb lighter than the previous M-38A1 jeep and has higher horsepower, acceleration, top speed, economy and cruising range.

These improvements have been made possible largely by using lightweight metals, high yield strength steels, and new manufacturing techniques. In conjunction with welded unit-body construction, the use of a high yield strength steel saves over 130 lb of weight and produces a more rigid body. Also, the magnesium wheels used on the MUTT weigh one-half as much as steel wheels. These wheels have successfully proved their durability after extensive tests, and corrosion problems have been greatly overcome by using tough, durable coatings which also resist abrasion under severe conditions.

Lightweight amphibians are highly mobile in water and on land

Designed to replace the famous World War II DUKW, the new LARC-5 and LARC-15 (Lighter, Amphibious, Resupply, Cargo) are general purpose, unarmored, low ground pressure vehicles that can operate on inland waterways, over all types of normal and adverse terrain, and in arctic and tropic zones. These versatile vehicles, soon to be in production, are made almost entirely of aluminum—about 7500 to 8800 lb for the LARC-5, according to current estimates. Aluminum was selected for the entire hull structure to achieve rigidity and lightness without cutting performance.

Another outstanding lightweight Army vehicle is the T-116 tracked amphibious cargo carrier. This vehicle can operate in almost any environment and can carry a 3000 lb-payload or a 12-man infantry squad; or it can serve as a litter for four patients or as a prime mover. It has a cruising range of 200 to 300 mi. Its low weight (7000 lb) and high mobility are achieved to a great extent by widespread use of lightweight materials.

For example, the T-116's hull is a welded aluminum structure containing magnesium floor plates and a glass-reinforced plastic cab and rear structure. In an effort to further reduce its weight, the Ordnance Corps is investigating forged aluminum track shoes (shown) which weigh one-third less (a matter of 300 lb) than conventional welded steel shoes without sacrificing service life or durability.

Wear, of course, is a major problem with lightweight metal shoes, and their success will depend on the development of alloys with improved properties. Nevertheless, experience obtained with aluminum track shoes on the T-116 may point the way to applications for other Army vehicles. Also, although aluminum shoes produce considerable weight savings, the Army is looking to reduce weight still further; thus suspension systems using magnesium track shoes are under close investigation.

U. S. Army photo

LARC-5 amphibious cargo carrier

T-116 tracked amphibious cargo carrier

Aluminum armor provides better protection on personnel carrier

M-113 Armored Personnel Carrier

U. S. Army photo

The Army has been devoting considerable research to lightweight ballistic armor made of aluminum, magnesium-lithium alloy, titanium, plastics, fabrics and composites. One of the most successful fruits of this research is the new M-113 armored personnel carrier whose aluminum armor provides better protection than the steel armor used on its M-59 predecessor. The M-113 is made from 5000 series aluminum which enables the hull to be made nine times as rigid as a steel hull of equivalent weight and eliminates the need for stiffening beams or structures (an aluminum model is shown at the right in the accompanying photo; the model at the left is made of steel).

Additional weight savings are obtained by using aluminum brackets, pads and appurtenances which weigh two-thirds as much as equivalent steel parts. These materials advances, plus more efficient engineering, have reduced the weight of the M-113 by more than one-half that of the previous M-59 armored personnel carrier.

Self-propelled howitzer contains 18,000 lb of aluminum

T-196 self-propelled 105mm howitzer

U. S. Army photo

Experimental magnesium trunnion

The success obtained with aluminum armor has led to a whole new series of lightweight combat vehicles, notably the T-195E1 105mm and T-196E1 155mm self-propelled howitzers. In addition to weighing 18,000 lb less than its predecessor (the M-44), the T-196E1 has greater range and better ballistic protection. Even though the T-196E1's diesel engine weighs more than the corresponding gasoline engine, substantial weight savings were obtained by using lightweight materials throughout, such as aluminum armor, hull, turret and wheels, and reinforced plastics fuel tanks. In all, a total of 19,000 lb of aluminum is used in the 47,000-lb vehicle.

Studies are underway to even further reduce weight. The trunnion casting for the T-196E1 is currently made from steel and weighs over 1000 lb. Tests of a new cast magnesium trunnion (shown) weighing only 363 lb are underway and have been quite successful to date.

M-60 tank is vastly improved with no weight increase

Lightweight materials are being applied across the board in ordnance equipment, from the smallest to the largest vehicles. Notable success has been obtained with the new M-60 main battle tank which weighs the same as the old M-48A2 medium tank but which is a vastly superior weapon. Through the use of lightweight materials it can carry a larger gun (a 105mm rather than a 90mm), has a greater cruising range and can provide better armor protection. Substantial weight savings were obtained by using aluminum wheels and two aluminum fuel tanks (shown) each of which weighs 500 lb less than an equivalent steel tank. The basket, ammunition racks and other appurtenances are also made out of aluminum to reduce weight. Even the top deck of the engine compartment is aluminum armor.

M-60 main battle tank

U. S. Army photo

This article is based in part on a paper entitled "Materials for Combat and Tactical Vehicles," presented by Mr. Salter at the Army Day Session of the Fall Meeting of AIME, Philadelphia, Nov '60.

The Role of Materials in Cryogenics

M/DE Special Report **No. 185**—*July, 1961*

- *How and where materials are being used in cryogenic solid state devices*
- *How engineering properties are affected by ultra-low temperatures*
- *How to evaluate and test materials for cryogenic applications*

by Donald Peckner and Malcolm W. Riley,
Associate Editors, Materials in Design Engineering

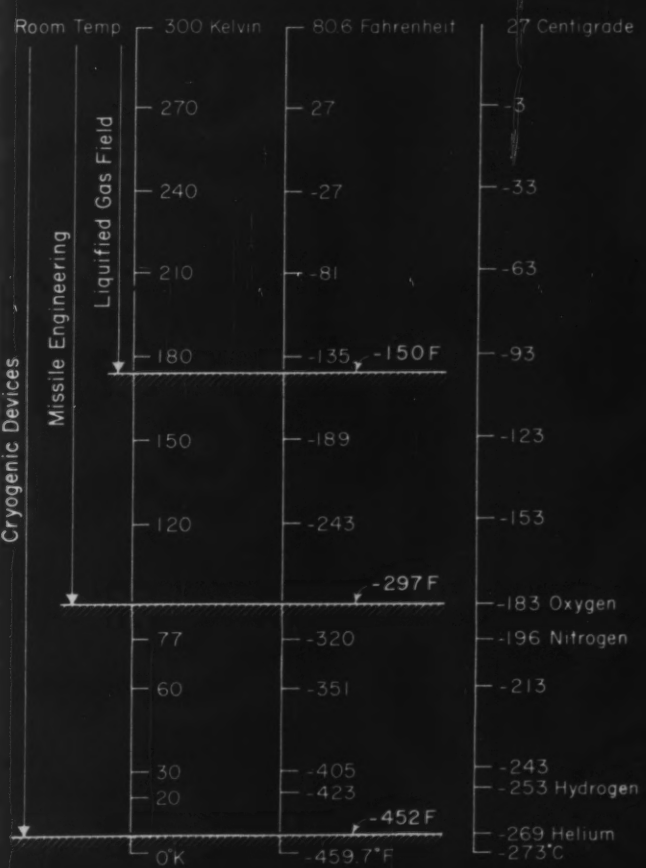
■ In the much publicized field of cryogenics, materials have come to play two important roles.

First, by taking advantage of the unusual "functional" or electronic properties exhibited by materials at extremely low temperatures, engineers and scientists have opened up a whole new technology. Thus, at temperatures aproaching absolute zero, electrical conductivity of certain metals increases many fold, low "thermal" noise is attainable in paramagnetic materials, and liquid helium exhibits superfluidity. It is these phenomena and others that are now being applied in the fields of electronics, bearing technology and motor design, and in such new devices as cryotrons, cryosars, masers and lasers.

The second role played by materials in the cryogenic field is perhaps just as important as the first. To take advantage of the unusual cryogenic phenomena, it is necessary that structural materials used in cryogenic equipment and structures perform satisfactorily at these extremely low temperatures. Therefore, advances in cryogenics have created a new set of materials problems in the design and manufacture of devices, and in the liquefaction, processing and handling of gases. Similar materials problems also have arisen in the rocket and missile field where fueling and storage systems must operate at cryogenic temperatures.

Where cryogenics starts

The term "cryogenics" needs some defining. How cold is a cryogenic temperature? Actually, it depends on the engineering field involved. The temperature scales below indicate the maximum temperatures usually considered to be cryogenic by each specialized field.



Materials in Solid State Devices

"A whole new set of phenomena are hopefully hiding in materials." This attitude, as expressed by Dr. H. C. Gatos of MIT's Lincoln Laboratory, reflects the feeling of many materials scientists about cryogenic phenomena in materials. It also reflects the youth of the science.

Most scientists feel that the surface has only been scratched. Much of the work is still empirical, based on an as yet incomplete understanding of the nature of the effects. For example, although good basic theories have been advanced to explain such phenomena as superconductivity, according to Gatos "the last word on its nature has not been said."

All functional effects of ultra low temperatures in materials deal with either transport phenomena or effects of transitions among energy levels within the materials. As materials are cooled to temperatures approaching absolute zero, internal motion of electrons, atoms and molecules decreases. Under these conditions unusual effects are manifest. Those that stand out, at our present state of limited knowledge, are 1) superconductivity, 2) increases in electrical resistance of certain semiconducting materials, 3) low "thermal noise" levels in paramagnetic materials, and 4) the unique, but as yet unutilized, superfluidity of liquid helium.

The discussion that follows is highly simplified, intended only to present a general picture of where we stand in putting these effects to practical use.

Superconductivity

Although discovered about 50 years ago, superconductivity is only now emerging from the status of a laboratory curiosity. Its most immediate practical use appears to be in 1) switching devices, such as small high speed logic and memory elements for computers, and as amplifiers and rectifiers, and 2) cryogenic magnets. Other potential uses include frictionless bearings for motors and gyroscopes, magnetic lenses for electron microscopes, oscillators, and possibly in power equipment.

In brief, superconductivity is the complete lack of measurable electrical resistance occurring in certain elements and alloys at temperatures approaching absolute zero (the highest temperature at which superconductivity appears at present is about 18 K in a columbium-tin alloy).

This complete lack of resistance, or electrical friction, means that with a very low power source, current can be started in a superconductor, and, when the power source is removed, the current continues to flow unabated indefinitely. The current creates a magnetic field around the superconductor which also stays constant indefinitely. All applications for superconductivity at present depend on this magnetic phenomenon.

Superconductivity is affected or controlled by two parameters: temperature and magnetic field. A material's transition temperature is the temperature below which the material is superconductive. A material's "critical field strength" is the strength of a magnetic field required to quench the material's superconductivity and return the material to its normal resistive state. Critical field strength differs in different materials, and in any given superconductor it increases with decreasing temperature. The qualitative nature of these two parameters is shown in Fig 1.

The critical field strength applies to either an externally applied magnetic field, or the magnetic field set up by the current in the superconductor. That is, superconductors are self-quenching. Should the current set up in the superconductor be sufficiently high to induce a magnetic field exceeding the critical field strength of the material, resistivity is restored. When quenching fields are removed, the material again becomes superconductive.

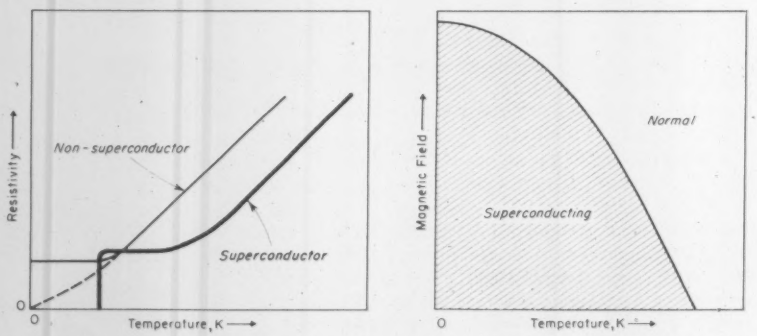
Where we stand in materials

At present, there are 25 elements and more than 250 metal alloys and compounds that exhibit superconductivity at temperatures from 18 K down to near 0 K. Table 1 lists some of these materials and their transition temperatures.

One of the most recent and interesting superconducting material is a columbium-tin alloy. It has one of the highest transition temperatures presently known, about 18 K. Since critical field strength of supercon-

TABLE 1—SOME SUPERCONDUCTIVE METALS AND COMPOUNDS
(Transition Temp at Right in K)

Titanium	0.53
Cadmium	0.56
Zirconium	0.70
Uranium	0.8
Zinc	0.91
Aluminum	1.20
Thorium	1.39
Thallium	2.38
Indium	3.37
Tin	3.73
Mercury	4.15
Tantalum	4.4
Vanadium	5.1
Lead	7.22
Columbium	8
Technetium	11.2
Nb_3Sn	18
NaBi	2.2
Mo_3Re	10.5
LiBi	2.5
PbAsBiSb	9.0
Wood's metal	8.2



1—Qualitative curves show change in resistivity with temperature (left), and change in critical field strength with temperature (right). Dotted line in resistivity curve for non-superconductor shows theoretical decrease to zero which pure metals should display. (General Electric Co.)

ductors increases with decreasing temperatures, the new alloy has an extremely high critical field strength at temperatures close to 0 K. For example, at 4 K, a critical field strength of 88,000 gauss has been reported; strengths of 100,000 gauss are reportedly likely.

An important problem with the columbium-tin alloy is its brittle nature, making fabrication extremely difficult. Recently (Apr, '61) a series of relatively ductile superconducting alloys of molybdenum and technetium were announced by Bell Telephone Laboratories. According to Dr. B. T. Matthias, such an alloy becomes superconducting at temperatures near 16 K. Other alloys, recently reported by Bell, include columbium-titanium, vanadium-titanium, and a columbium-zirconium alloy which remained superconducting in a field of 80,000 gauss while carrying a current of 10,000 amp per sq cm.

Switching devices

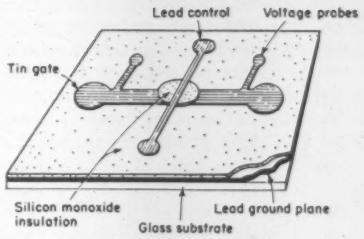
The ability to "turn off" and "turn on" resistivity in a superconductor by applying and removing a magnetic field (quenching and unquenching) has led to the development of switching devices called cryotrons which should be useful in computers.

Cryotrons are superconductive four-terminal switching devices in which a magnetic field, produced by passing a current through two input terminals, controls the resistance between two output terminals.

In simple terms, two superconducting materials of different transition temperatures and critical field strengths are used. Altering the current in one, and thus altering its magnetic field, controls the resistivity in the other. As pointed out by *Buck* and *Buchhold*, the superconductive-resistive states of the cryotron correspond to the binary "on" and "off" states of ordinary computer elements.

A memory element can be constructed by arranging cryotrons in a circuit that will support a persistent circulating current. Either a binary ZERO or binary ONE is stored depending on the direction of the current. The direction of the circulating current can be determined nondestructively by measuring the direction of the associated magnetic field.

The most promising development in cryotrons is the thin-film cryotron produced by deposition of thin films



2—*Configuration of a thin-film cryotron used for testing a single cryotron. (A. D. Little)*

of superconductive materials on a substrate such as glass. The thin film superconductors thus replace the superconducting wire in wire-wound devices. Such thin-film cryotrons can be produced in much smaller sizes, have faster switching times, and are more easily fabricated than wire-wound cryotrons. Typical configuration of a thin-film cryotron is shown in Fig 2.

Cryogenic magnets

The major benefits of using superconductive windings in electromagnets would be substantial reductions in power requirements, elimination of heating, and reduction in size. As pointed out by *Arp and Kropschot*, since all the Joule heating in a conventional electromagnet is wasted, use of a superconducting magnet would result in a power saving ranging from about 5 kilowatts for a laboratory magnet to perhaps 10 megawatts for the largest existing magnet. Also, less power required would substantially reduce weight and the cost of fabrication, maintenance and control.

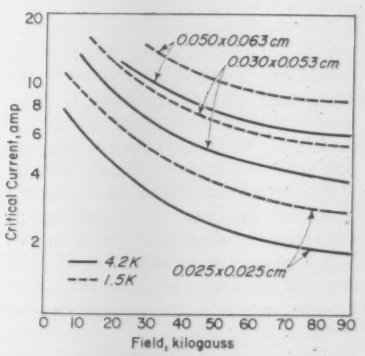
Possible applications for cryogenic magnets include use in masers, particle accelerators, particle focusing, bubble chambers, and plasma confinement in a thermonuclear reactor.

The major problem to be overcome in developing superconductive magnets is the limitation imposed by the superconductor's critical field. The maximum magnetic field obtainable in an air-core superconducting magnet or solenoid is the critical field of the superconductive material, since the inner windings experience the maximum field of the solenoid.

The critical field strength for any given material is not a constant, however, but depends on the density of the electrical current in the conductor (current per unit cross section), generally decreasing as the current density increases. Since efficient solenoid design calls for the greatest possible current density, which results in a reduced critical field strength, the designer must compromise between these conflicting factors. Under these circumstances it is significant to note that the new columbium-tin alloy has shown superconductivity when exposed to a field of 88,000 gauss, which is much higher than the critical field of either columbium (3000-8000 gauss) or tin (about 300 gauss) alone. Further, this high value was measured at current densities exceeding 100,000 amp per sq cm.

According to *Kunzler, et al*, of Bell Laboratories, who reported these findings, existing theory does not account for their observations. Fig 3 shows critical current vs applied magnetic field for three dimensions of columbium-tin wire measured at 1.5 and 4.2 K. (Data were obtained by selecting a fixed value for magnetic field and slowly increasing current through the sample until a potential drop of a few hundredths of a microvolt indicated appearance of resistance.)

At the time of writing, maximum reported magnetic fluxes generated with cryogenic magnets of useful size have been reported by Dr. S. H. Autler of MIT's Lincoln Laboratory with columbium superconductors, although a small experimental air-core solenoid at Bell Telephone Laboratories, using a molybdenum-rhenium alloy, has developed a field strength of 15,000 gauss. In air-core coils Autler reports fields of 10,000 gauss at 1.5 K and 7000 gauss at 4.2 K. In iron-core cryogenic magnets he reports exceeding 25,000



3—*Critical current vs field strength for three sizes of specimens of columbium-tin alloy superconductor.* *(Kunzler, et al)*

MIT, Lincoln Laboratory

Superconducting *solenoid coil, shown with its developer Dr. S. H. Autler, supplies magnetic field for a solid state maser. A 1.5-v dry cell battery is all that is required to start current in coil which can generate magnetic fields up to 6500 gauss.*

gauss at 4.2 K. No data are available as yet on magnets made with the newer columbium-zirconium, columbium-tin, or molybdenum-technetium alloys.

Experimental work has shown that the superconductor quenching field for thin films having a thickness less than the penetration depth (i.e., a measure of the depth of penetration of an applied steady magnetic field into the bulk of a superconductor—usually about 0.05 microns for most superconductors) is much greater than the quenching field of the bulk material. Thus, there remains a distinct possibility that large thin film superconducting magnets can be built to produce fields of over 25,000 gauss.

Other future uses

Other potential uses for superconductivity include frictionless bearings, motors and gyroscopes. Although the principles of these are relatively well known, the devices are only in the development stages.

All three of these devices are based on the "magnetic insulating" characteristic of superconductors. When an external magnetic field is brought near a superconductor it sets up eddy currents, and consequently a magnetic field, in a thin surface layer of the material. The latter magnetic field repulses the lines of force of the impinging magnetic field.

By proper design, both the rotor of a gyroscope and the shaft of a bearing made of superconductive materials can be supported on the magnetic flux caused by a superconductive coil. Increasing pressure on the rotor or bearing would increase the flux density, thereby increasing the current in the coil and amplifying the repelling force of the flux. Such a rotor or bearing would operate virtually without friction, and thus with maximum efficiency and minimum error.

A cryogenic motor based on this principle would, according to *Buchhold*, have a rotor with a polygonal cross-section, permitting superconductive coils to be located around it in such a way as to produce the torque.

Other possibilities include superconductive magnetic lenses, which when applied to an electron microscope might have such increased resolution that we might actually see the atom; use of superconductive power transmission that would permit carrying of unheard of loads in a very small conductor. Development of many such devices must wait for the discovery of superconductors with transition temperatures high enough to permit cryogenic cooling with more economical liquefied gases such as hydrogen or nitrogen.

Lower conductivity

Although certain materials are superconductors at cryogenic temperatures, certain semiconductors have increased resistivity at such temperatures. For example, at liquid helium temperatures (4.2 K) specially doped germanium may have a resistivity as high as 10^8 ohm-cm, since carriers which were mobile at room temperature are almost all attached to the impurity centers.

This characteristic has been put to use in a device termed the "cryosar." According to *McWhorter and Rediker*, cryosars are high-speed two-terminal computer components whose operation at 4.2 K is based on impact ionization of impurities in germanium. As a voltage is applied, the free carriers gain sufficient energy in the electric field to ionize the impurities upon impact. At some critical electric field, the impact ionization rate exceeds the recombination rate and a reversible, nondestructive breakdown occurs, similar in many respects to avalanche breakdown in a gas.

As a result of avalanche breakdown, essentially all the impurities are ionized and the resistivity is decreased by as much as seven orders of magnitude. When the electric field drops below the critical value, high impedance is restored by recombination of the carriers with the ionized impurities. Thus the name "cryosar," derived from low temperature (*cryo*) switching by *a*valanche and *r*ecombination.

Two types of cryosars are under development. The first uses uncompensated germanium of high resistivity at 4.2 K, whose current increases by as much as seven orders of magnitude when a critical field is applied. The second using compensated *p*-type germanium, has similar electrical characteristics except that a negative resistance region occurs between the high and low impedance states, making bistable operation possible.

The first type of cryosar can perform the functions of a diode, the second type can be used as a memory element, multi-vibrator, or flip-flop. Both types are fast, speed being limited only by the turn-on time of 10^{-8} seconds or less.

Cryosars appear to offer a high degree of reliability and reproducibility, since their performance is due to bulk effects, and only ohmic contacts must be applied to the germanium wafer. Also, they are extremely small. It should be possible to fit 200,000 in a cubic inch on a stack of germanium wafers.

Low noise for masers and IR

The low level of atomic activity at near-absolute zero results in low "thermal noise." This low noise level in paramagnetic materials is useful in masers (*m*icrowave *a*mplification by *s*timulated *e*mission of *r*adiation), permitting the amplification of electromagnetic signals so weak that they would be smothered by thermal noise at room temperature. Lasers operate on essentially the same principle (*l*ight *a*mplification by *s*timulated *e*mission of *r*adiation).

The solid state maser essentially consists of a paramagnetic material, such as a ruby crystal, a "pumping system" to provide a microwave power supply, a magnetic coil to provide the paramagnetic material with a magnetic field, and a cryogenic cooling system.

A unique and highly efficient combination of cryogenic effects has been obtained by using a supercon-

ducting open-core cryogenic solenoid to provide a readily adjustable magnetic field. Current flows in the superconducting coil, which is immersed in a Dewar flask along with the paramagnetic material and liquid helium. When the coil circuit is closed in the cryogenic environment and the power supply is disconnected, the current that continues to flow in the superconducting coil produces a magnetic field of very great stability. The liquid helium provides the low temperature to maintain both the superconductive state in the coil (and the resulting magnetic flux) and the low noise level in the paramagnetic material.

Major benefits of such a system include: 1) only a modicum of power is needed to start the current in the superconductive coil, and once started, no further power is required, and 2) the system is greatly reduced in weight, since heavy electromagnets are eliminated. Cryogenic coils for one such maser weigh only 6 oz, compared with 100 lb or more for a comparable electromagnet.

IR detection systems — Low thermal activity at cryogenic temperatures also greatly improves efficiency of infra red detection systems. According to *Tyler and Potter*, recent developments have produced IR detector materials with improved detection out to the 40μ wavelength region. To realize maximum sensitivity to wavelengths above about 6μ, detecting elements must be cooled to temperatures ranging from 4 to 200 K. In the shorter 2 to 6μ region, lesser degrees of refrigeration are required.

Design Properties at Cryogenic Temperatures

What happens to the mechanical properties of solids at cryogenic temperatures? With few exceptions, the strengths are greater at low temperatures than at room temperature. This generalization applies both to crystalline and noncrystalline solids as well as to materials such as glass reinforced plastics. Strength of metals at –425 F may be 2 to 5 times greater than at room temperature; noncrystalline plastics may be 1.5 to 8 times stronger at –323 F than at room temperature. Glasses do not show this large increase; at –325 F they are 1.5 to 2 times as strong.

Yield strength of materials that are ductile at low temperatures increases with decreasing temperature. Metals with face centered cubic or hexagonal close packed crystal structures have yield strengths at –423 F that are 1 to 3 times higher than room temperature values. Body centered cubic metals, on the other hand, undergo a ductile to brittle transition and below their transition temperature fail at stresses below the yield.

The trend of fatigue strength and hardness follows the same pattern.

Ductility of nearly all plastics and some metals decreases with temperature. Ductility of fcc metals is relatively independent of temperature, but metals with other crystal structures, especially the bcc type, tend to be brittle at cryogenic temperatures.

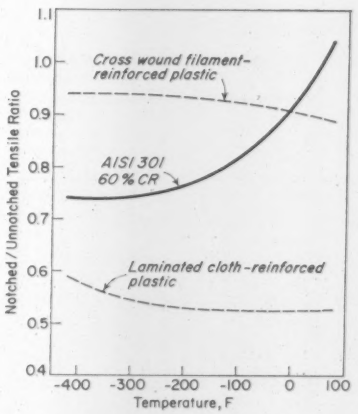
One method for evaluating ductility is to measure notched/unnotched strength ratios. Table 2 is a compilation of these ratios as well as the important measure of potential structure weight: yield strength/density ratios.

The notched/unnotched strength ratio decreases for metals as temperature decreases. Although specific data are not presented in Table 2, Fig 4 does show that we can expect the reverse behavior in plastics as temperature decreases.

Table 3 shows how elastic constants of different metals vary with decreasing temperature. Interestingly enough, constants were dynamically measured by ultrasonic techniques. These elastic moduli are important when elastic deformation of a component must be limited by design requirements. The data allow alloys to be compared on a modulus/density ratio basis.

With the exception of some reinforced plastics and fluorocarbons, plastics are not generally specified for cryogenic applications.

As we just pointed out, there are many groups of metals, but only a few plastics, which can be considered for service in cryogenic environments. In this section we will discuss the mechanical and physical properties of suitable materials.



Notched to unnotched tensile ratios of two reinforced plastics and AISI 301 stainless steel.

(Lewis Research Center, NASA)

Metals: Wide choice

The difference shown by fcc and bcc metals has been an important factor in determining which families of metals can be considered for structural use at cryogenic temperatures. Those normally considered include: copper, nickel, all of the copper and nickel alloys, aluminum and its alloys and the austenitic stainless steels. All of these materials remain ductile at cryogenic temperatures. However, martensitic nickel steels with a bcc structure have been developed for service at temperatures as low as –320 F.

In addition to the commonly used materials, some cobalt, titanium and magnesium alloys, as well as tantalum, also retain considerable ductility at –423 F and lower.

Aluminum and its alloys

The attraction of aluminum alloys for cryogenic applications lies in their excellent strength-to-weight ratios and ductility at temperatures down to –423 F. In addition, most aluminum alloys are readily fabricated and joined, another important consideration when designing for cryogenic environments.

Mechanical properties—Table 4 compares typical tensile properties of eleven aluminum alloys at room temperature and –423 F. Tensile and yield strength increase significantly at —423 F while ductility varies. The high strength 7000 series alloys show a decrease in ductility which may hinder their use at cryogenic temperatures. The reduction in ductility may be caused by

inclusions, but this point will require further investigation.

The low ductility of cast 355 alloy, along with other data not reported here, raises a question concerning the usefulness of aluminum castings in cryogenic environments.

Austenitic stainless steels

Austenitic stainless steels have been used extensively for applications down to –423 F and below because they do not become embrittled. Heat treatable, precipitation hardening stainless steels are not usually recommended for cryogenic applications because of embrittlement. Fig 5 shows how the tensile strength and elongation of five commonly used stainless steels varies from room temperature down to –450 F.

There are two conditions—sensitization and cold work—to consider when applying the austenitic stainless steels. Sensitization, or precipitation of carbides at the grain boundary, is not a serious problem relative to room temperature mechanical properties. As Fig 6 shows, however, the effect becomes more serious at –300 F. High cold reductions (60% and over) which raise room temperature mechanical properties can result in transformation of austenite to martensite. The martensite has a bcc structure and is inherently brittle at cryogenic temperatures.

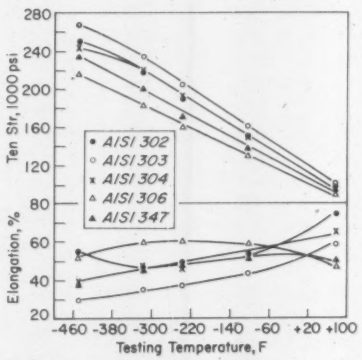
Copper and nickel-base alloys

In general, the behavior of copper, nickel and their alloys closely follows

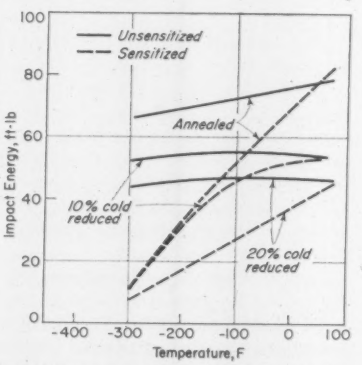
TABLE 2—YIELD STRENGTH-DENSITY RATIOS AND NOTCHED-UNNOTCHED RATIOS OF SHEET ALLOYS

Alloy	Thk, in.	Cold Red., %	Test Temp, F	Yld Str-Density Ratio, 10^6 in.	Notched-Unnotched Strength Ratio, (K_t = 6.3)
Stainless Steel					
Type 301	0.020	40	78	0.59	1.05
			–423	—	0.92
Type 301	0.016	50	78	0.63	1.01
			–423	0.86	0.87
Type 301	0.032	60	78	0.64	1.08
			–423	1.00	0.94
Type 301	0.015	80	78	1.00	0.73
			–423	1.46	0.57
Type 301-N	0.017	60	78	0.63	1.06
			–423	0.96	0.82
Type 302	0.020	40	78	0.55	1.07
			–423	0.75	0.69
Type 302	0.020	60	78	0.62	1.08
			–423	0.86	0.95
Type 304ELC	0.012	50	78	0.55	1.09
			–423	0.80	1.09
Type 310	0.020	40	78	0.48	1.10
			–423	0.69	1.00
Type 310	0.020	60	78	0.53	1.03
			–423	0.80	1.06
Type 310	—	75	78	0.55	1.10
			–423	0.88	1.11
Aluminum					
2024-T3	0.025	—	78	0.48	0.89
			–423	0.73	0.81
5052-H38	0.040	—	78	0.41	1.07
			–423	0.57	0.90
5086-H34	0.040	—	78	0.38	1.02
			–423	0.50	0.75
5154-H38	0.040	—	78	0.42	1.04
			–423	0.56	0.83
6061-T6	0.020	—	78	0.44	1.05
			–423	0.56	0.93
7178-T6	0.036	—	78	0.83	1.02
			–423	1.11	0.51
Titanium					
Ti-5Al-2.5Sn	0.040	—	78	0.70	1.34
			–423	1.43	0.97
Nickel-Base					
K-Monel (aged)	0.020	—	78	0.32	0.93
			–423	0.45	0.99
Hastelloy B	0.011	40	78	0.53	1.15
			–423	0.72	1.09
Cobalt-Base					
Haynes 25 Alloy	0.020	20	78	0.38	1.03
			–423	0.63	0.98
Haynes 25 Alloy	0.008	40	78	0.65	0.83
			–423	0.94	0.69

Source: Watson and Christian, ERR-AN-003, Convair Astronautics Div.



5—*Tensile properties of austenitic stainless steels increase at cryogenic temperatures.*
(De Sisto and Carr, Watertown Arsenal Laboratories MS-22)



6—*Temperature affects impact properties of sensitized type 302 stainless steel.*
(McClintock and Gibbons, NBS Rpt. 6064)

that of the austenitic stainless steels. Fig 7 shows that the tensile properties of cold drawn high purity copper are excellent at –423 F. No specific data have been found for unalloyed nickel at –423 F, but excellent properties can be predicted on the basis of performance at –320 F. The alloys of both copper and nickel also perform well at cryogenic temperatures.

TABLE 3—ELASTIC CONSTANTS OF ALLOYS AT LOW TEMPERATURES

Material	Temp, F	Young's Modulus, 10^6 psi	Bulk Modulus, 10^6 psi	Shear Modulus, 10^6 psi
Aluminum	75	10.2	11.0	3.8
	–105	10.6	10.9	4.0
	–319	11.1	11.4	4.2
	–452	11.4	11.3	4.3
Magnesium	75	6.3	5.5	2.4
	–105	6.7	5.4	2.6
	–452	6.9	5.6	2.7
Molybdenum	75	42.8	36.0	16.5
	–105	43.6	36.6	16.8
	–319	44.1	36.6	17.0
	–452	44.5	36.3	17.2
AISI 4340 (annealed)	75	29.8	23.4	11.5
	–105	30.2	23.4	11.7
	–319	30.9	23.3	12.1
	–452	31.8	22.7	12.5
Type 301 Stainless Steel	75	29.7	25.6	11.4
	–105	31.6	26.2	12.2
	–319	31.9	25.9	12.3
	–452	32.3	26.0	12.5
Titanium (commercially pure)	75	15.1	14.7	5.7
	–105	16.4	15.1	6.3
	–319	17.1	14.9	6.5
	–452	17.3	14.7	6.6
Ti-6Al-4V	75	16.1	15.4	6.1
	–319	17.7	14.7	6.8
	–452	17.8	14.6	6.9
Ti-7Mn	75	16.0	14.3	6.1
	–105	16.8	14.7	6.4
	–319	17.2	14.5	6.8
	–452	17.9	15.1	6.9

Source: Fahey, Watertown Arsenal Laboratories TR 118.111.

TABLE 4—TYPICAL TENSILE PROPERTIES OF 11 ALUMINUM ALLOYS AT ROOM TEMPERATURE AND –423 F

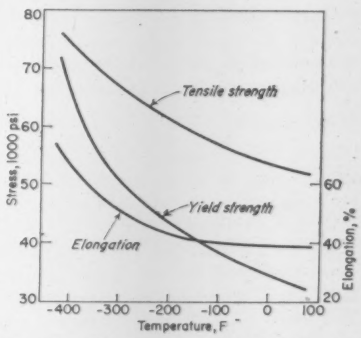
Alloy ↓	Room Temperature			–423 F		
	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
1100-H14	18	16	22	47	21	—
2014-T6	70	60	10	95	85	10
2024-T3	75	57	20	110	80	20
2219-T62	58	39	11	92	54	14
5052-0	30	14	30	70	—	60
5052-H34	29	26	10	75	33	40
5456-H34	57	40	14	96	53	22
6061-0	20	15	16	55	15	30
6061-T6	48	48	16	75	55	25
7075-T6	75	69	12	105	97	6
7079-T6	75	60	12	95	82	4
7178-T6	90	84	12	123	112	8
355-T6	50	44	3	71	62	2.5

Source: The Martin Co.

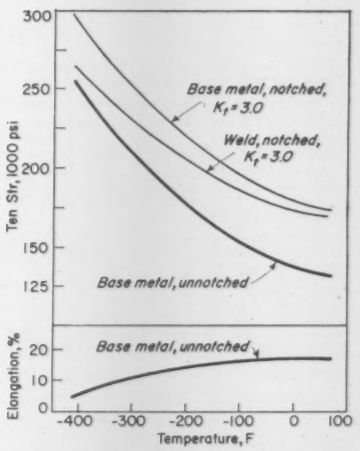
Titanium

Because of the high strength-density ratios that can be achieved with some titanium alloys (see Table 1), particularly at temperatures below –423 F, considerable interest has been shown in these alloys for cryogenic applications. Three types of microstructure are exhibited by titanium alloys: alpha hexagonal close packed); alpha-beta (hexagonal close packed and body centered cubic); beta (bcc).

The alpha alloy Ti-5A1-2.5Sn is preferred for use at temperatures down to –423 F. Mechanical properties are shown in Fig 8. Other alpha alloys such as Ti-5A1-5Zr-5Sn, Ti-5A1-4Zr-1V, Ti-8A1-2Cb-1Ta and Ti-7A1-12Zr can be used but the



***7**—Tensile properties of cold drawn OF copper increase as temperature decreases.*
(McClintock and Gibbons, NBS Rpt. 6064)



***8**—Tensile properties of annealed and welded Ti-5Al-2.5Sn sheet, 0.050 in. thick.*
(Day and Mitchell, Titanium Metals Corp. of America)

Ti-5A1-2.5Sn alloy is considered more suitable.

Alpha-beta alloys such as Ti-6A1-4V have been used for such cryogenic applications as helium pressure bottles and in the LOX tanks of some missiles. The beta alloy Ti-13V-11Cr-3A1 is not recommended for use below –60 to –70 F.

Magnesium

To date, use of magnesium base alloys for cryogenic applications has been limited. Tensile strength and elongation of five magnesium alloys as shown in Fig 9, ranges from 45,000 psi to 72,000 psi at –423 F. Elongation ranges from 4 to 11% and impact values are generally low, less than 5 ft-lb.

Tantalum

Table 5 shows that tantalum, useful as a high temperature metal, also retains high ductility and strength down to –423 F. It is important to protect the metal from contamination in order to develop the properties shown in the table.

Alloy steels

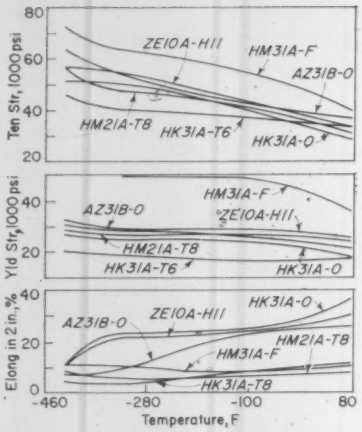
Steel compositions, with a bcc crystal structure and generally high transition temperature, are not suitable for cryogenic structures. An alloy steel containing 9% nickel has been developed for service at liquid nitrogen temperatures (–320 F). The steel—ASTM A353—shows an almost uniform elongation of 22% down to –320 F (see Fig 10). At a recent demonstration, a tank fabricated from ASTM A353 steel was filled with liquid nitrogen and pressurized to failure at approximately 2200 psi. The failure was non-catastrophic in that the tank burst, but did not shatter.

On a cost basis, the 9% nickel steel offers designers a material with a high allowable stress. Table 6 compares the relative cost of tanks made from aluminum alloys, stainless steel and ASTM A353.

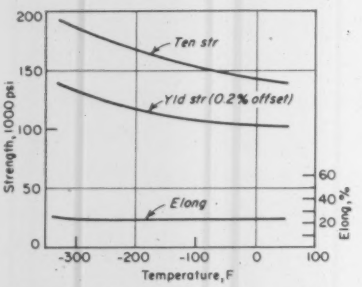
TABLE 5—TENSILE PROPERTIES OF TANTALUM BAR VS TEMPERATURE

Test Temp, F	Yld Str, 1000 psi	Ten Str, 1000 psi	Elong, %	Notched Str, 1000 psi[a]
Wrought and Stress Relieved				
RT	55	61	28	95
–100	82	82	32	128
–320	159	159	16	226
–423	208	208	—	293
Recrystallized				
RT	24	35	65	54
–100	51	51	48	86
–320	—	104	—	163
–423	112	132	28	197

[a] K_t=3.
Source: Imgram, Holden, Ogden and Jaffe, WADD TR60-278.



9—*Tensile properties of magnesium base alloys at cryogenic temperatures.* (Reed, et al)



10—*Tensile properties vs temperature for normalized and stress relieved 9% nickel steel, ASTM A-353.* (U. S. Steel Corp.)

Nonmetallics: Choice is limited

Mechanical properties of plastics increase as temperature decreases. Table 7 shows that modulus of elasticity and strength-to-weight ratio also increase. The increase in modulus of elasticity improves structural properties but makes contour conformance and sealing more difficult to attain.

Glass

At room temperature and below, the strength of glass for a given load duration increases with decreasing temperature. Fig 11 shows that little or no fatigue exists in borosilicate crown glass (BSC-2) at temperatures below –323 F.

Insulating materials

Selecting an insulation for cryogenic applications greatly influences equipment design. The same insulation is not necessarily the best for all uses—which may range from storage vessels, transport vessels, transfer lines and missiles to laboratory apparatus. Insulations are generally of four types: vacuum, multiple layer, evacuated powder and rigid plastic foams. Neglecting vacuum insulation, here is a brief description of the remaining three:

Multiple layer—Consisting of alternate layers of good reflectors separated by poor conductors, the best results have been obtained with aluminum foil separated by thin glass paper. Conductivity is approximately 1/10 that of the best evacuated powder insulation. Area of greatest potential is in transport vessels for two reasons: payload of the vessel is increased and the multiple layer super insulation can be used for structural support. In stationary equipment, evacuated powder is competitive because of its ease of installation.

Evacuated powder—Consisting of finely divided powders such as silica aerogel, expanded perlite, calcium silicate and diatomaceous earth, evacuated powders are easy to install and inexpensive (relative to the cost of the cryogenic installation). They can be used at pressures as low as 10^{-3} mm Hg. Although the vacuum requirement is less restrictive than that required for the super insulations ($>10^{-5}$ mm Hg), problems develop both in drying the powders and evacuating gases normally found in the powders.

Rigid foam—Foams can be made of polystyrene, polyurethane (isocyanate), rubber, glass, silica and other materials. Although used extensively in refrigeration, their use in cryogenic applications is limited by high thermal conductivity relative to vacuum, multiple-layer or evacuated powder types.

Plastics and elastomers

Fluorocarbons (TFE, CFE) are the most promising plastics materials for cryogenic applications and have been used in such applications as bearing surfaces for liquid air systems and gaskets for use in LOX systems. Their properties are

discussed in the section devoted to testing (see below).

Use of elastomers in static seals at cryogenic temperatures has been extensively investigated by the National Bureau of Standards. If the elastomer is sufficiently deformed at room temperature, the seal is effectively retained below the brittle point of the plastic. Fig 12 shows that if initial compression is above 50 to 70%, sealing force does not go to zero at the brittle point but levels off at some positive value.

Fig 13 indicates that phenolic-epoxy adhesives are effective bonding agents down to –423 F. Honeycomb composites can be fabricated without difficulty and reinforced plastics can be bonded to metal sections to fabricate liquid hydrogen containers.

TABLE 6—RELATIVE WEIGHT AND COST OF ALUMINUM AND STEEL CRYOGENIC TANK MATERIALS

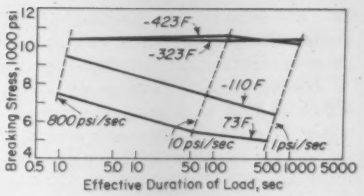
Material →	Stainless Steel	Aluminum Alloys		ASTM A-353	
	Type 304	5456-0	5083-0	Grade A	Grade B
ASME Allowable Design Stress, psi	18,750	10,500	10,000	22,500	23,750
Equiv Wall Thickness	0.312	0.562	0.585	0.261	0.246
Equiv Wt., psi	12.85	7.76	8.09	10.52	9.92
Relative Wt., %	100	61	63	82.3	77.2
Material Cost, cents per lb	70	65	60	33[a]	33[a]
				31.5[b]	31.5[b]
Equiv Cost, psf	6.55	3.72	3.88	3.47	3.27
Relative Cost, %	100	57	59	53.6	50.5

[a]Double normalized and tempered.
[b]Quenched and tempered.
Source: U. S. Steel Corp.

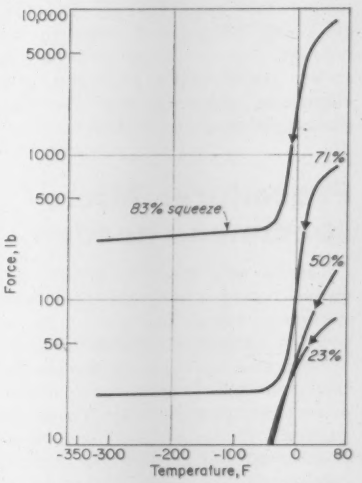
TABLE 7—CRYOGENIC TEMPERATURES RAISE PROPERTIES OF PLASTICS

Laminate	Temp, F	Ten Str, 1000 psi	Ten Modulus, 10^6 psi	Strength/Weight Ratio, 10^5 in.
Phenolic Glass (Coast F-120-14)	77	56.3	2.7	8.45
	–320	95.4	3.0	14.3
Polyester Glass (U. S. Polymeric C)	77	57	2.9	8.55
	–320	95.4	3.0	14.3
Silicone Glass (Coast F-130-14)	77	38.8	2.8	5.81
	–320	76.8	2.8	11.5
Epoxy Glass (Coast F-150-14)	77	60.7	2.9	9.1
	–320	107.5	4.3	16.1
Polyester Glass (181 Selectron 5003)	77	41.8	3.2	6.27
	–320	70	3.7	10.5

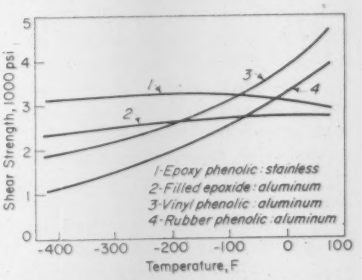
Source: The Martin Co.



11—*Stress-time-loading rate characteristics of borosilicate glass (BSC-2). Fatigue is almost non existent below –323 F.* (Kropschott)



12—*Force-cooldown diagrams after various compressions.* (Weitzel, et al.)



13—*Strength of adhesives decreases as temperature decreases.* (Frost)

Problems in Evaluating and Testing Plastics

by J. H. Lieb, *Research Specialist, and* **R. Mowers,** *Research Engineer, Materials Engineering, Rocketdyne, Div. of North American Aviation, Inc.*

Ultra-low temperature testing of materials creates problems in all three phases of materials testing: equipment, procedure, and evaluation of results.

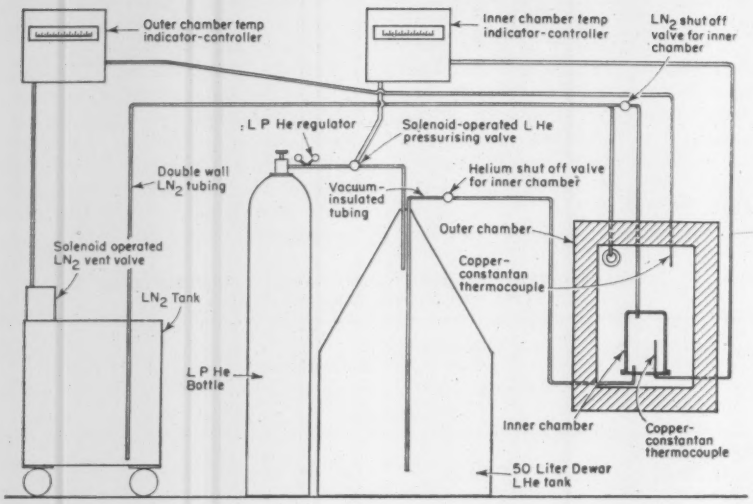
In equipment, the problem is one of obtaining the extreme environment. In procedure it is one of obtaining specimens adaptable to the limitations of the equipment. In evaluation, it is one of correlating values obtained with properties of that material in its design shape.

Equipment: How to get cold

A great deal of effort is being spent developing more efficient cryostats (essentially "refrigerators" for providing cryogenic environments). At present, Rocketdyne has apparatus available for evaluating materials at –320 F (77 K, or liquid nitrogen temperature), and is modifying equipment to test at –423 F (20 K or liquid hydrogen temperature). The chambers, or cryostats, are fitted to a 10,000 lb Instron universal test machine. Tests carried

out at –320 F are performed in liquid nitrogen, or in a circulating gaseous nitrogen atmosphere at its boiling point. Testing at above –320 F is done with gaseous nitrogen.

Fig 14 shows a schematic of a test set-up for testing at temperatures down to –423 F. Essentially, it consists of an outer chamber cooled with liquid nitrogen (–320 F), and an inner chamber cooled with liquid helium (–452 F) and/or liquid hydrogen (–425 F), depending on temperature requirements. The use of liquid helium and nitrogen as coolants is more expensive than a system using liquid hydrogen, but eliminates the necessity for explosion-proofing the system.



14—*Schematic of test set-up for testing at –423 F.*

Procedure: Micro-specimens needed

Tensile and flexural microspecimens, rather than standard size specimens, reduce the size of chamber and amount of cooling medium needed, and substantially reduce the time required to get the specimen down to test temperature. These are particularly important considerations because of plastics' low thermal conductivity.

Also, microspecimens can be cut directly from prototype or production parts, such as propellant gate-valve lip seals, which are too small to provide full-size ASTM specimens. The important effects of fabrication variables and part size on mechanical properties of plastics, as discussed later, makes such a procedure highly desirable. Fig 15 shows dimensions of the tensile microspecimen developed, compared with those of ASTM D412 Die C and Die D.

TABLE 8—CORRELATION OF TENSILE VALUES: MICRO VS STANDARD SPECIMENS* (CFE Fluorocarbon)

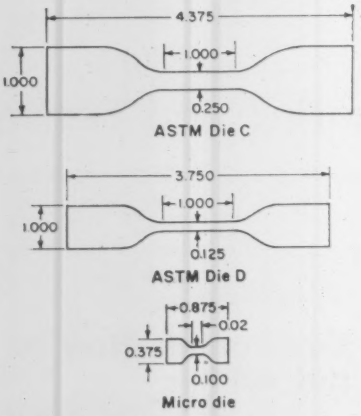
Die Type ↓	Ten Str, psi	Elong, %
Cross-Head Speed: 2 ipm		
Die C	5380	68
Die D	5530	68
Micro Die	5520	45
Cross-Head Speed: 1 ipm		
Die C	5400	97
Die D	5530	96
Micro Die	5500	97

*Values are averages of three 0.062-in. thick specimens each from 12 sheets of Kel-F, quick-quenched from 550 F to produce comparable crystallinity levels (i.e., Rockwell R15T 72 ±5, as described later).

Tensile tests were conducted to determine whether tensile values from the microspecimen would correlate with those of standard specimens. Table 8 shows correlation in tensile strength and elongation values for CFE fluorocarbon obtained with the three different specimens.

As can be seen, at 1 in.-per-min cross-head speed consistent correlation was obtained on both tensile strength and elongation measurements. At speeds of 2 in.-per-min, tensile strengths correlated well, but no correlation existed in elongation values.

At the 2 in.-per-min speed and higher, any slight jaw misalignment caused premature failure of the microspecimen. This was reflected in elongation readings rather than tensile strength values, because maximum tensile strength is attained in such materials before ultimate elongation. Thus, all tensile testing of microspecimens of plastics is performed at a testing speed of 1 ipm or less.



15—*Dimensions of micro die, compared with Die C and D.*

Correlation: Crystallinity big problem

Outstanding among the limited number of plastics retaining some ductility at ultra-low temperatures are the fluorocarbons, e.g., TFE (i.e., Teflon), FEP (i.e., Teflon X100), and CFE (e.g., Kel-F). One of the most important factors our studies revealed about these materials is the dependence of mechanical properties at cryogenic temperatures upon the crystallinity of the material. And, as is well known, crystallinity of such materials is critically dependent on final design shape and processing history.

Consequently, mechanical properties of a test specimen with a certain crystalline content will not be indicative of the mechanical properties of a molded or extruded part of a different crystalline content

Significance of crystallinity

At –320 F fluorocarbons of low crystallinity, high amorphous content, are stronger and more ductile than highly crystalline materials. This dependence of mechanical performance on crystallinity would not be important except for the related dependence of crystallinity on shape,

size and processing history. For example, a part of small cross-section (e.g., less than ⅛ in. thick) of crystallite-forming material can be produced with almost any degree of crystallinity desired. Rapid quenching from above the material's melting point produces minimum crystallite formation; gradual cooling results in maximum crystallite growth.

In quenching thicker sections, inner portions of the section are insulated by the outer skin and cannot be cooled rapidly enough to avoid crystallite growth. Consequently, a part of thicker section would be higher in crystalline content and thus lower in strength at cryogenic temperatures.

For maximum utility, then, cryogenic design data for such materials as fluorocarbons, should be available for materials of all levels of crystallinity. The materials engineer, knowing the configuration and dimensions of his final part and the method of fabrication can predict the crystallinity level, and pick off the properties the material will display at that level of crystallinity.

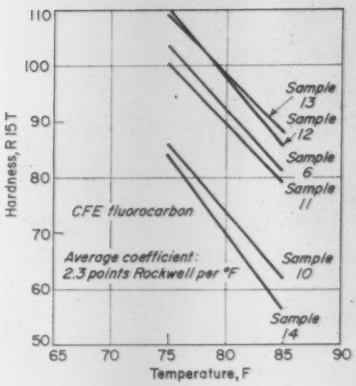
Simple, fast test developed

X-ray diffraction and infra-red absorption techniques are the two methods generally used for determining relative crystallinity of high polymers. Unfortunately they involve expensive and complex equipment and highly skilled technicians to analyze and reduce the data for use. Also, since special specimens are required, fabricated parts cannot be tested without destroying them.

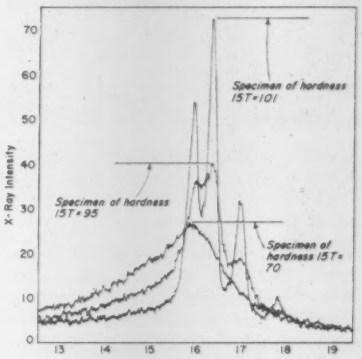
On the other hand, an ideal test would 1) be fast, simple and accurate, 2) be nondestructive, 3) yield immediately usable results which would be insensitive to operator and environmental changes, 4) be sensitive enough to discern small differences in crystallinity of the polymer, and 5) use equipment normally available and operable by nontechnical personnel.

Since hardness generally increases with crystallinity, a number of tests based on hardness were evaluated. The test method that evolved was a Superficial Rockwell hardness test, using a 15 kg major load and a 1/16-in. dia steel ball penetrator. The test met all the requirements, except that it was sensitive to minor temperature changes. However, standard correction curves, shown in Fig 16, have been developed for CFE to correct values to a consistent temperature. (Average coefficient is found to be 2.3 points Rockwell per deg F.)

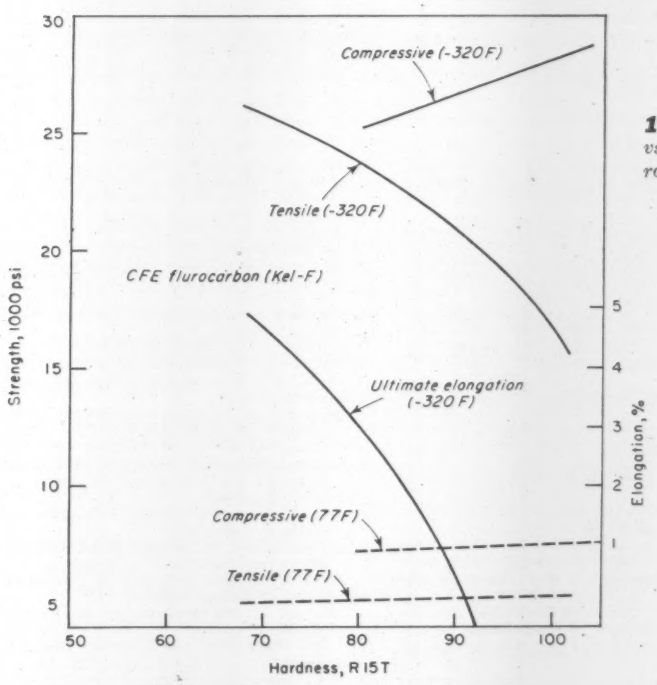
Because of the greater suscepti-



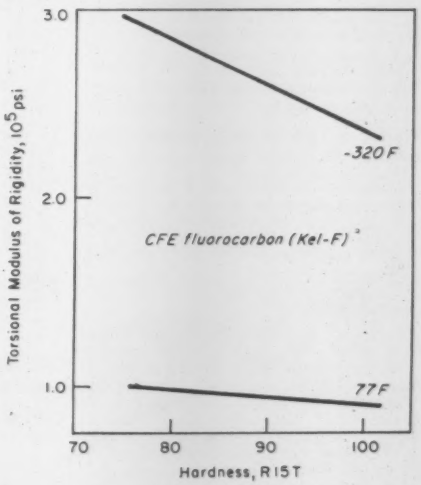
16—*Correction curves for Kel-F to compensate for effects of temperature on hardness values.*

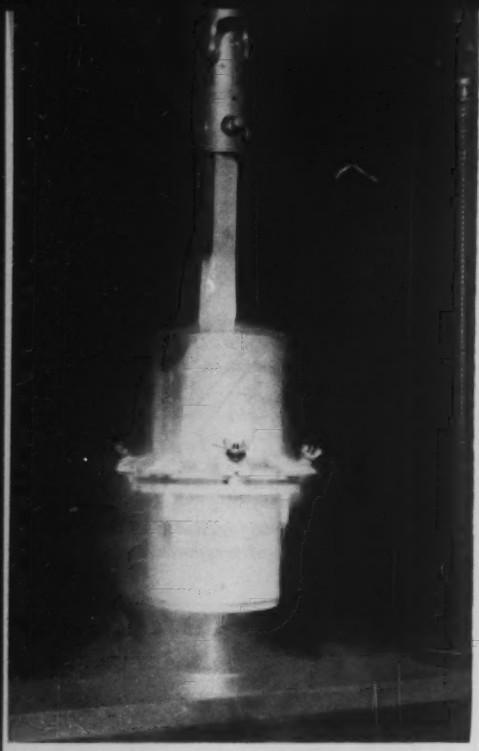


17—*Correlation at 3 hardness levels with x-ray diffraction curves.*



18—*Strength (left) and torsional modulus (below) vs hardness as indicative of crystallinity at both room temperature and –320 F for CFE fluorocarbon.*





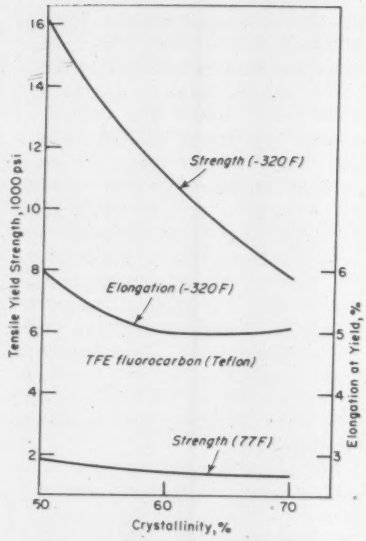
Liquid nitrogen-cooled *chamber for testing microspecimens at –320 F.*

bility of plastics than metals to indentation, time of load application must be precisely controlled and repeated for reproducible results. After release of the major load, an arbitrary recovery period of 10 sec is allowed to elapse before the reading is made.

Correlation good

Qualitative correlation between results of this simple hardness test and x-ray diffraction tests is excellent. We found the test to be as accurate and sensitive as x-ray diffraction. Curves in Fig 17 show hardness values of 70, 95 and 101 for CFE specimens correlating with increasingly higher intensity peaks by x-ray diffraction. That is, the higher the crystallinity of the material, the higher the x-ray intensity, and the greater the hardness. The total hardness spread obtainable with this method (e.g., from 60 to over 100 for CFE material ranging from amorphous to highly crystalline) is large enough so that small differences in crystallinity levels can be determined readily.

Fig 18 plots tensile and compressive strength, ultimate elongation and torsional modulus of rigidity of a CFE fluorocarbon vs crystallinity as measured by the hardness test, at both room temperature and —320 F. Fig 19 plots tensile strength and elongation of TFE fluorocarbon vs percent crystallinity (as determined by Du Pont).



23—*Tensile yield strength and elongation of TFE fluorocarbon vs crystallinity at room temperature and –320 F.*
(E. I. du Pont de Nemours & Co., Inc.)

Cryogenic index useful

For design purposes an index, describing the relationship of a given property at cryogenic temperatures to the same property at room temperature is useful. Such a cryogenic index can be found by dividing the property value at a given cryogenic temperature by the value for that property at room temperature and multiplying by 100.

For example, for TFE fluorocarbon of 50% crystallinity the tensile cryogenic index (at —320 F) would be 870; for Mylar-type polyester film the value would be about 150. A similar index can be established for elongation. For example, elongation cryogenic index for a CFE of a crystallinity (as measured by the hardness test) of R15T 68 would be 3.2.

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Watertown Arsenal

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first in silicones

Dow Corning

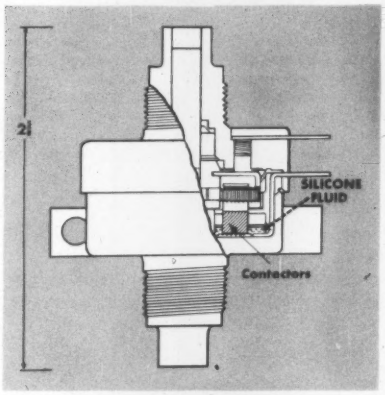
SILICONE NEWS

for design and development engineers · No. 84

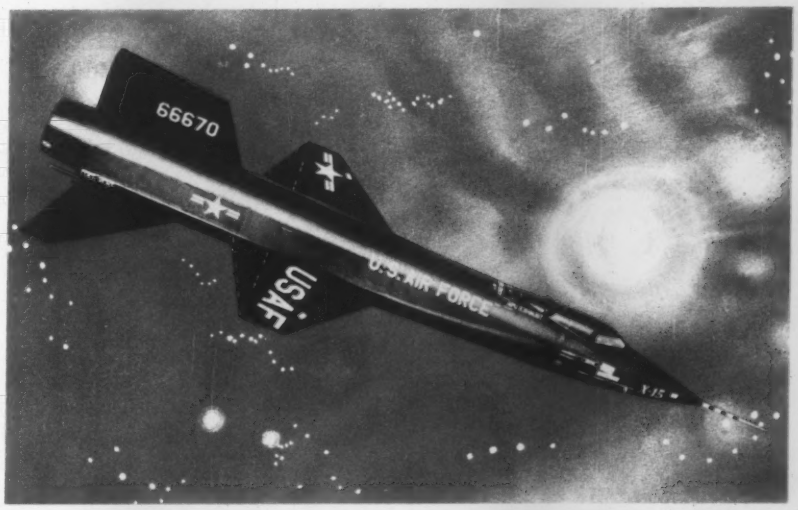
SLO-O-W MOTION

To sense extremely slow motion — or lack of motion — requires a detector that retains uniform sensitivity despite fluctuations in ambient temperatures. And that means silicones according to the designers who engineered the Micro Motion Detector manufactured by Gaylord Controls, Division of Gaylord Products Inc., Chicago. Here's how they describe this super-sensitive unit.

"Detection of motion is accomplished by a set of equally spaced hydrodynamically responsive electrical contactors driven by a common shaft. When driven at or above



a fixed speed, the contactors plane on the surface of a pool of Dow Corning silicone fluid. When shaft speed is *(Cont. Pg. 2)*



Probing Space At 3600 MPH

The X-15 provides a testing ground for both men and materials preparing for manned space flights. One of the successful materials is Silastic® LS, the Dow Corning fluorosilicone rubber that helps simplify designs because of its exceptional resistance to fuels, oils and solvents.

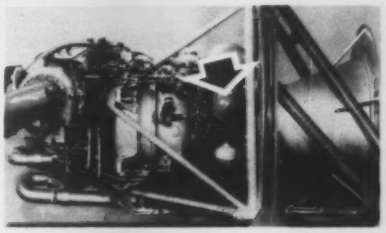
Engineers of Reaction Motors Division of Thiokol Chemical Corporation specified an accumulator diaphragm of Silastic LS for the X-15's XLR-99 engine. The accumulator provides oil at a constant pressure to the lube oil pump. Gaseous nitrogen under pressure is the source of stored energy, and is separated from 4-11V Halocarbon oil by the Silastic LS.

Here are diaphragm requirements the designers established as essential: An elastomer that—

1. **is flexible from —80 to 200 F;**
2. **is compatible with the lube oil at low and elevated temperatures;**
3. **will not contaminate lube oil.**

Silastic LS . . . the only elastomer to meet all these requirements . . . helps the X-15 as it knocks on the door to outer space.

Shown below is the XLR-99 rocket engine. The lube oil accumulator is the light weight type . . . made possible by the diaphragm of Silastic LS . . . instead of the heavy, bulky piston type. Parts of Silastic can be engineered to meet your specific needs by your rubber fabricator. For more information about oil and solvent resistant Silastic parts, circle **No. 241**

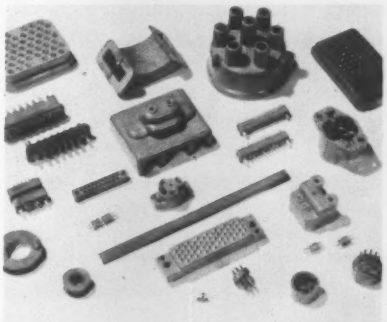


700 F PARTS MADE EASY

A new, thermosetting silicone compound that forms easily into rigid parts capable of 700 F service is now obtainable from Dow Corning. Designated M-6-4156, the new material makes possible high accuracy, low cost parts that are capable of withstanding exceptionally rigorous service.

Using this mineral-filled silicone molding compound, fabricators can mold parts directly into finished shapes, without costly machining. Finished parts exhibit outstanding characteristics:

- long-term dimensional stability at 700 F;
- excellent resistance to thermal shock; (from —67 to 500 F)
- low dissipation factor of 0.002 at 10^6 cps;
- high arc resistance, over 400 seconds.

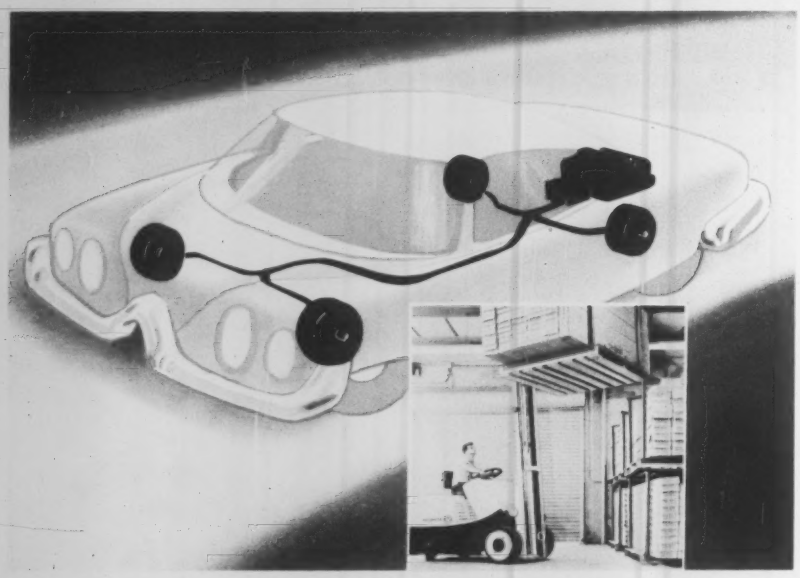


Suggested applications include: fuses and fuse holders, coil forms, relay parts, tube bases, terminal parts, contactors, arc barriers, tube sockets, switch parts, and other close-tolerance ceramic parts.

Fabricators report this new *(Cont. Pg. 2)*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

MORE



Electric Autos, How Soon?

Another significant straw in the wind of what may be in store for American automobile owners is presaged by introduction of a new line of electrically-driven fork lift trucks by Automatic Transportation Company, Chicago.

Current for the traction motors driving these materials handling trucks is supplied by a variable voltage generator powered by a gasoline engine. The synchronized power package supplies fast, smooth pick-up at the touch of the accelerator. The trucks are capable of traveling 8.5 m.p.h. . . . will start or stop on 28% ramps when fully loaded.

Electric propulsion has eliminated the need for a clutch, fluid coupling, fluid torque converter or multiple speed transmission. Result — lower operating costs, increased efficiency, less maintenance and potentially fewer costly repairs.

Automatic engineers place their reliance on traction motors insulated with Dow Corning Silicones because they provide greater power-per-pound and greater reliability than drives insulated with any other material. Silicone insulation provides a more generous service factor (for reliability) than is possible with any other insulating material.

If you can use more power in a smaller package, or increased efficiency with the ultimate in dependable operation, you should be looking into silicone insulated motors. Drives insulated with silicones are already at the forefront in the development of new traction motors for trucks, earth moving machines, materials handling equipment, mining machinery and locomotives. Perhaps, one day, the family car will head the list! *No. 242*

SILICONE COMPOUND *(Cont.)*

Dow Corning silicone molding compound is exceptionally easy to use. Even complex and intricate shapes are quickly and economically fabricated using established techniques with conventional compression or transfer molding equipment. For more information, circle . . . . . *No. 243*

new literature on silicones

ALL NEW BROCHURE describes how Syl-off (silicone) coated papers save time and money for packagers and users of sticky products. Illustrates applications as package liners, process papers, interleaving and slip sheets. Also includes samples of coated papers plus listing of approved sources for paper products made with Syl-off coatings. *No. 245*

FIRST AVAILABILITY! ***"How Silicones Aid the Rubber Industry"*** is a production-engineering guide to the Dow Corning Silicones most useful in producing rubber and plastic materials and parts. This new eight-page manual is a concise, comprehensive reference to the ways silicones keep production on schedule, make better products, minimize scrap, speed handling and reduce maintenance and downtime. *No. 246*

Silicone Adhesives Really Stick . . . Anywhere! From —80 to 500 F, pressure-sensitive silicone adhesives withstand moisture, oxidation, weathering, corrosive chemicals, arcing, corona, and fungus; have excellent dielectric strength. Excellent for use on tapes, as sealants, spray-on coatings, bonding materials and splicing agents. *No. 247*

SILICONE FLUID *(Continued)*

reduced, the contactors break through the fluid medium and make electrical contact with the terminal plate. When shaft speed is increased the contactors emerge through the fluid and contact is broken.

"If deceleration is at a slow rate, the contact closes at approximately zero RPM; if extremely rapid, as with a brake, contact is made a fraction of a second after zero shaft speed is reached. When the shaft is accelerated slowly, the contact opens at about 8 RPM; accelerated at a higher rate, the contact opens instantaneously."

From this description, it is quite obvious that the fluid medium must retain near-uniform viscosity over wide temperature ranges, must be oxidation-resistant, non-gumming, and must withstand shear without viscosity breakdown. That's why Gaylord engineers specified Dow Corning silicone fluid.

For detailed information on properties and applications, circle . . . . . *No. 244*

Dow Corning Corporation, Dept. 7419, Midland, Michigan

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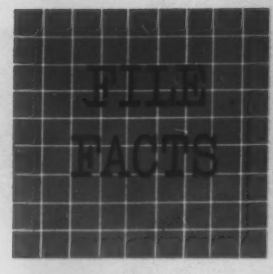


Corrosion Resistance of Nickel Alloy Castings

Corrosive Medium ↓ / Alloy →	Martensitic	Ferritic		Austenitic					Hastelloys			Others			
	CA-15 (12 Cr, 1 Ni)	CB-30 (20 Cr, 2 Ni)	CC-50 (28 Cr, 4 Ni)	CE-30 (29 Cr, 9 Ni)	CF-20[a] (19 Cr, 9 Ni, 0.2 C)	CH-20 (25 Cr, 12 Ni)	CK-20 (25 Cr, 20 Ni)	CN-7M (20 Cr, 29 Ni)	B[b]	C[c]	D[d]	Illium G[e]	Nickel (unaerated)	64 Ni, 31 Cu	71 Ni, 16 Cr
Acetic Acid															
10%	4	4	4	2	2	2	2	1	1	1	1	1	3	3	1
99.9%	5	5	5	3	3	3	3	1	1	1	1	1	3	3	2
Aluminum Acetate	4	4	4	2	2	2	2	1	1	1	1	1	3	3	2
Aluminum Chloride	5	5	5	5	5	5	5	4	1	3	2	3	2	2	2
Aluminum Hydroxide	4[f]	4[f]	4[f]	4[f]	4[f]	4[f]	4[f]	2	1	1	1	1	2	2	2
Aluminum Sulfate															
10%	5	5	5	3	3	3	2	1	1	1	1	1	3	3	3
Saturated	5	5	5	5	5	4	4	1	1	1	1	1	5	5	3
Alum															
10%	5	5	5	3	3	3	2	1	1	1	1	1	3	3	3
Saturated	5	5	5	4	4	3	3	1	1	1	3	1	5	5	4
Ammonium Bicarbonate	3	2	2	1	1	1	1	1	1	1	1	1	2	2	2
Ammonium Carbonate	3	2	2	1	1	1	1	1	1	1	1	1	2	2	2
Ammonium Chloride															
10%	3[f]	3[f]	3[f]	2[f]	2[f]	2[f]	2[f]	2[f]	1	1	1	1[f]	1	1	2[f]
50%	5	5	5	4[f]	4[f]	4[f]	4[f]	2[f]	2	1	2	1[f]	1	1	2[f]
Ammonium Nitrate	2	2	2	1	1	1	1	1	2	1	2	1	5	5	1
Ammonium Sulfate															
10%	4	4	4	2	2	2	2	1	1	1	1	1	3	3	3
Saturated	5	5	5	3	3	3	3	1	1	1	1	1	3	3	3
Bromine Liquid (dry)	5	5	5	5	5	5	5	3	3	2	3	3	1	1	1
Bromine Liquid (H_2O sat.)	5	5	5	5	5	5	5	4	3	2	3	3	3	3	3
Bromine Water (dil.)	5	5	5	5	4	5	5	3	2	2	2	3	5	5	5
Calcium Chloride	5	5	5	5	5	5	5	4	3	1	3	3	2	2	2
Calcium Hypochlorite	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5
Chlorine Gas (moist)	5	5	5	5	5	5	5	4	3	1	3	3	5	5	4
Copper Sulfate	4	3	3	2	2	1	1	1	4	1	4	1	4	4	2
Ethylene Glycol	3	3	3	2	2	2	2	1	1	1	1	1	2	2	1
Fatty Acids	300 F	300 F	300 F	400 F	400 F	400 F	400 F	600 F+	600 F+	600 F+	400 F	600 F+	400 F	400 F	600 F
Ferric Chloride	5	5	5	5	5	5	5	5	5	2	5	5	5	5	5
Ferric Sulfate	4	4	4	3	3	3	3	2	5	2	5	2	5	5	3
Ferrous Sulfate	4	4	4	2	2	2	2	1	2	1	2	1	3	3	3
Formic Acid															
10%	4	4	4	2	2	2	2	1	2	1	2	1	2	1	2
100%	5	5	5	3	3	3	3	1	3	1	3	1	2	1	2
Hydrochloric Acid	5	5	5	5	5	5	5	5	2	5	5	5	3[g]	3[g]	4[g]
Hydrobromic Acid	5	5	5	5	5	5	5	5	2	3	5	5	5	5	5
Hydrofluoric Acid	5	5	5	5	5	5	5	4	4	3	4	4	4	1	4
Hydrogen Peroxide	3	3	3	2	2	2	2	2	5	3	5	2	3	4	2
Lactic Acid															
10%	5	5	5	3	3	3	3	1	4	2	4	1	3	2	2
100%	5	5	5	3	3	3	3	1	4	2	4	1	3	2	2
Magnesium Chloride	5	5	5	5	5	5	5	4[f]	1	1	1	3[f]	1	1	2[f]
Magnesium Sulfate	5	3	3	2	2	2	2	1	1	1	1	1	2	2	2
Nickel Chloride	5	5	5	4[f]	4[f]	4[f]	4[f]	3[f]	1	2	3	3[f]	2	2	3[f]
Nickel Nitrate	3	2	2	2	2	2	2	2	4	2	5	2	5	5	3
Nickel Sulfate	5	5	5	3	3	3	3	1	2	1	2	1	2[f]	2[f]	2
Nitric Acid															
20%	3	2	2	1	1	1	1	1	5	3	5	1	5	5	3
100%	5	4	4	4	4	4	4	3	5	5	5	3	5	5	3
Oxalic Acid															
10%	4	3	3	2	2	2	2	1	2	1	3	1	3	2	3
50%	5	4	4	3	3	3	3	1	3	1	4	1	3	2	3
Phosphoric Acid															
10%	3	3	3	1	1	1	1	1	1	1	1	1	4	1	3
85%	5	4	4	3	3	3	3	2	1	2	2	2	4	3	3
Potassium Sulfate	4	3	3	3	3	3	3	1	1	1	1	1	3	1	2
Sodium Carbonate	4	3	3	2	2	2	2	1	1	1	1	1	1	1	1
Sodium Chloride	5	4[f]	4[f]	3[f]	3[f]	3[f]	3[f]	1[f]	1	1	1	1[f]	2	1	2[f]
Sodium Hydroxide															
20%	4	4	4	1	1	1	1	1	1	1	1	1	1	1	1
70-80%	5	5	5	5	5	5	5	270 F	1	1	1	270 F	1	1	1
Sulfuric Acid															
10-20%	5	5	5	5	5	5	5	2	1	1	1	2	4	2	3
90-100%	4	4	4	3	3	3	3	250 F	300 F	250 F	300 F	250 F	4	4	3
Zinc Chloride	5	5	5	5	5	5	5	2[f]	1	2[f]	1	2[f]	2	1	2[f]

Key: 1—Good resistance to boiling; 2—Good resistance to 160 F; 3—Good resistance to 120 F; 4—Good resistance to 70 F; 5—Not recommended.

[a]This is one of a class of alloys (CF alloys) containing about 19% Cr, 9% Ni, and less than 0.2% C. They are by far the most widely used group of corrosion resistant stainless steels.

[b]2.5 Co, 1 Cr, 26-30 Mo, 4-7 Fe, 1 Si, 1 Mn, 0.05 C, bal Ni.

[c]2.5 Co, 14.5-16.5 Cr, 15-17 Mo, 3-4.5 W, 4-7 Fe, 1 Si, 1 Mn, 0.08 C, bal Ni.

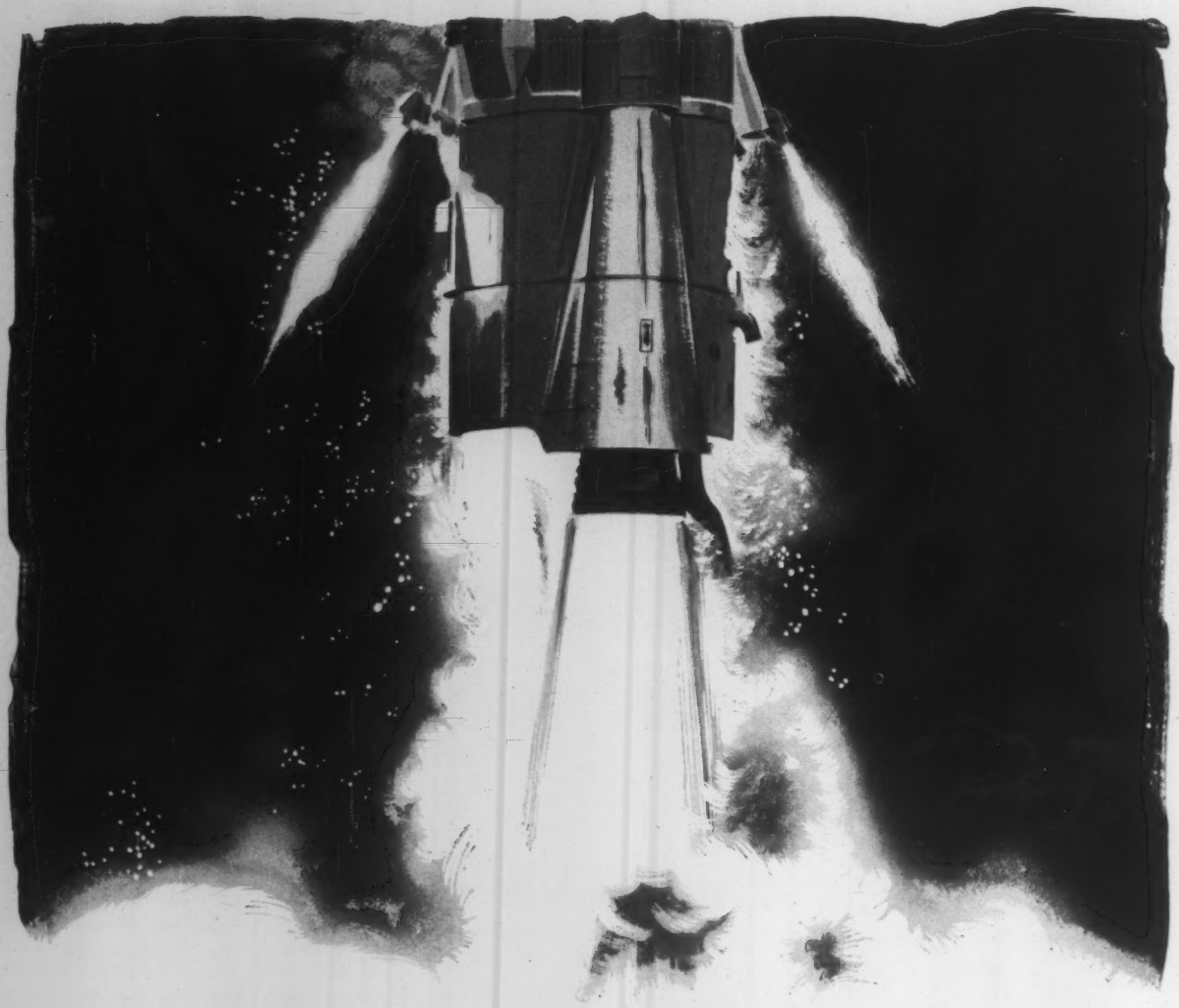
[d]11 max Si, 4 max Cu, bal Ni.

[e]Contains over 50% Ni and 20% Cr, along with smaller percentages of other alloying elements.

[f]Subject to pitting.

[g]Dilute concentrations.

Data supplied by International Nickel Co.



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R/M asbestos-phenolic parts are used in virtually every U.S. missile. They exhibit a highly desirable combination of properties such as low thermal conductivity and diffusivity, low rate of ablation, high strength-to-weight ratio, excellent shock resistance and structural integrity.

Asbestos-phenolic felts, mats and molding compounds are available for prompt shipment from R/M in production quantities. And they are backed by comprehensive technical data and know-how. Write for complete information and engineering help.

Tape wound rocket motor tube liner of R/M Style 41RPD Pyrotex.®

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Reinforced Plastics Department, Manheim, Pa.

SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 325

Price cuts on cold rolled stainless steel strip have been announced by Allegheny Ludlum Steel Corp. New prices are 76.75¢ per lb for type 316 strip, down 4¢ per lb; 45¢ lb for type 301, down 2½¢ per lb; and 38.75¢ per lb for type 430, down 2¢ per lb. The price action has been followed by most other major producers.

A major ingredient used in a new tungsten gas plating technique—tungsten hexafluoride—is now available in commercial quantities from Allied Chemical Corp.'s General Chemical Div. The gas plating technique produces dense, pore-free coatings at rates up to 1 mil per min. It was developed by the National Bureau of Standards and the Bureau of Mines (M/DE, Dec '59, p 162, and Feb '60, p 6).

Price of a high density, extrusion-grade polyethylene has been reduced from 38¢ to 35¢ per lb by Hercules Powder Co. Other major polyethylene producers are expected to follow with similar price cuts. At the same time, Hercules announced that it has introduced a new 0.962 density polyethylene priced at 32¢ per lb.

More polyethylene will be available when Du Pont opens a new plant at Orange, Tex. The unit is expected to be completed in the third quarter of 1962, and will bring Du Pont's overall polyethylene capacity to nearly 400 million pounds per year. The new Texas plant will also produce a new vinyl resin called Elvax (see p 6, this issue).

Production of vacuum-degassed steel is increasing. Vacuum furnaces now in use are estimated to be capable of melting over 200 million pounds of steel and superalloys per year. Allegheny Ludlum Steel Corp. says that by the end of this year its Watervliet, N. Y. Works will be able to vacuum melt three million pounds of steel a month, 50% more than it could produce two years ago. And Bethlehem Steel Co. says all its steam turbine rotor and spindle forgings, as well as its electric generator shaft forgings, will be made from vacuum-degassed steel.

A complete roundup of current prices will appear in the September issue.

Price of square and rectangular copper magnet wire has been increased 1¢ per lb by Rome Cable Corp.

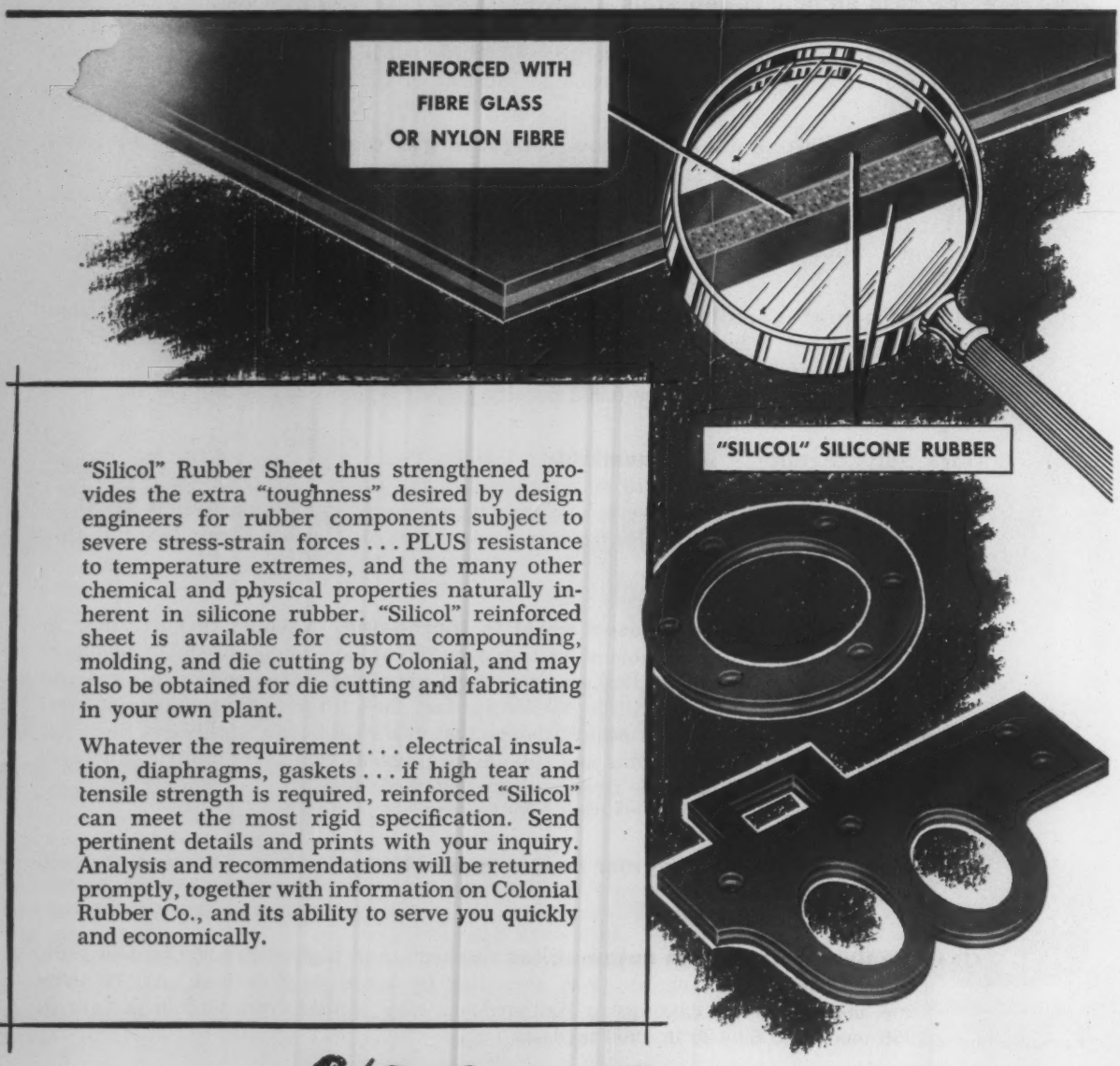
Use of galvanized steel in automobiles reached a new high of 218,960 tons in 1960, compared to 158,280 tons in 1959, according to American Zinc Inst. At the same time, use of zinc die castings in standard-size cars jumped from 60.5 lb per car in 1959 models to 69.4 lb in 1960 models.

Production of electrolytic copper foil will be doubled at the McConnelsville, Ohio plant of Cleveland Graphite Bronze Co., Div. of Clevite Corp., when new facilities are completed this fall. The foil, used for printed circuits, is produced in a continuous strip 78 in. wide.

•Design your seals and gaskets for

100% GREATER TENSILE and TEAR STRENGTH

with "SILICOL"* SILICONE RUBBER SHEET



"Silicol" Rubber Sheet thus strengthened provides the extra "toughness" desired by design engineers for rubber components subject to severe stress-strain forces . . . PLUS resistance to temperature extremes, and the many other chemical and physical properties naturally inherent in silicone rubber. "Silicol" reinforced sheet is available for custom compounding, molding, and die cutting by Colonial, and may also be obtained for die cutting and fabricating in your own plant.

Whatever the requirement . . . electrical insulation, diaphragms, gaskets . . . if high tear and tensile strength is required, reinforced "Silicol" can meet the most rigid specification. Send pertinent details and prints with your inquiry. Analysis and recommendations will be returned promptly, together with information on Colonial Rubber Co., and its ability to serve you quickly and economically.

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(cont'd from p 106)

Welding Improves Reliability of Miniaturized Electronic Circuits

Resistance welding instead of soldering the connections in most miniaturized electronic circuits is said to offer significant advantages in increased reliability, and reduced weight, size, and assembly time.

The principal advantages of welded over solder joints, according to a report by L. D. Armstrong, Space Technology Laboratories, Inc. are:

1. A homogeneous fusion of two metals is stronger and more shock and vibration resistant than a joint containing two interfaces plus an interconnecting metal.

2. As the welding current is applied only for a few milliseconds, connections can be made close to sensitive components. (Welded semiconductor junctions reach about 80 F compared to 120 F for soldered joints.)

3. Solderless miniaturized assemblies weigh significantly less than their soldered counterparts.

4. Welding permits up to a 50% decrease in size of assemblies by minimizing clearances needed between connections and leads.

5. Assembly time can be cut as much as 33%.

These conclusions were reported by Mr. Armstrong at the Fourth Symposium on Welded Electronic Packaging, held in March. He described Space Technology Laboratory's program for adapting welding to electronic circuits, redesigning circuit packages to take advantage of welded joints, and developing production techniques, and controls.

Adapting welding to circuits

The basic method for welding a typical miniaturized circuit consists of five steps:

1. The components are compactly clustered with their leads inserted through holes in insulating end wafers which are, in turn, fixed in a jig and separated with spacers.

2. Interconnections between parts are welded with fine wire or ribbon on the outer surfaces of the wafers.

3. Preliminary electrical tests are run.

4. The entire assembly is normally given a conformal plastics coating to hold the parts in place.

5. The spacers or fixtures are removed, and excess wafer, leads, and connecting wire clipped off. The circuit module can then be encapsulated if desired.

This method increases package density but requires a high degree of craftsmanship to assemble.

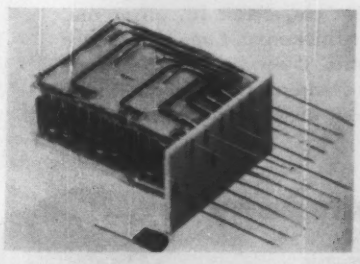
Designing circuits for welding

Use of welding greatly expands the package design possibilities for circuits.

One new method made possible by use of welding consists of assembling the interconnecting wires in a grid form. Two sets of parallel fine wires are assembled at right angles to each other and separated by a thin insulating film. Necessary interconnections of upper and lower wires are welded through small holes prepunched in the film.

The wiring diagram of the interconnections is first reproduced on the film. Dots show where holes are to be punched for interconnections.

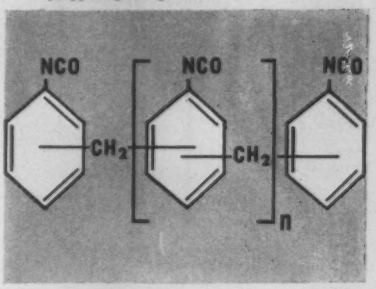
continued on p 126



***High density module** design permits three cascaded flip-flop circuits to be contained in a ½-cu in. space.*

papi®

(Polymethylene polyphenylisocyanate)



ONE SHOT RIGID FOAMS

High strength at ultra low density PAPI polyether fluorocarbon based foams for refrigerator insulation.

HOT STRENGTH

PAPI based rigid polyester foams **retain** their strength after prolonged exposure to temperatures above the useful range of conventional urethanes.

EXCELLENT ADHESION

PAPI provides **excellent adhesion** between butyl, nitrile, haloprene, and other rubbers and a variety of substrates like polyester fiber, nylon, metal.

SAFER

PAPI is a nonvolatile reactive isocyanate that is easily used even for spray-in-place foams.

THE CARWIN COMPANY
NORTH HAVEN, CONN

® T.M. Reg. U.S. Pat. Off.

Please send more data on PAPI.

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City_____ State_____

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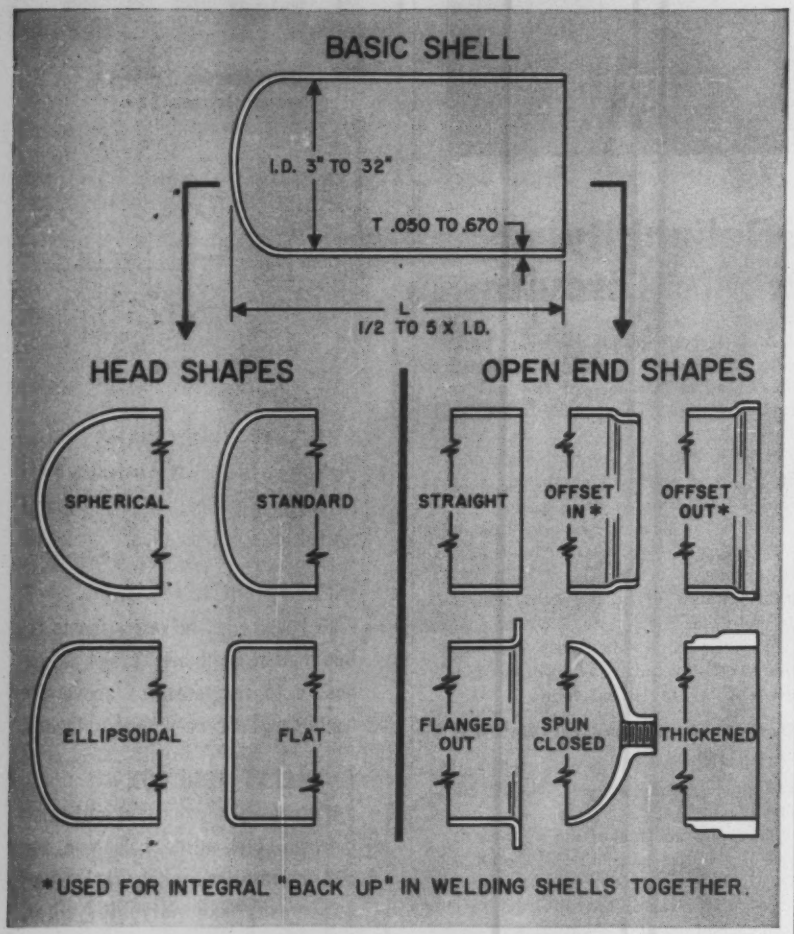
Your ideas...our methods...give you reliable components at low cost



The drawings shown here give you a simple description of the way you can use basic Hackney shells to produce a variety of seamless, lightweight, strong, low-cost rocket motor cases, gas generator housings, control actuator pressure vessels and other missile components.

The basic unit is a cold drawn, deep shell which has uniform wall thickness from top to bottom in ranges from .050″ to .670″. I.D.'s vary from 3″ to 32″. The length of the shell may be from ½ to 5 times the diameter—or up to 110″.

Head shapes—spherical, standard, ellipsoidal, flat or special. *Open end shapes* offer variety—straight cut, offset in, offset out, flanged out, flanged in, spun closed or thickened. *Capacities* begin at 1 quart—go as large as 100 gallons. *Working pressures* range from 100 to 6000 psi, depending upon diameter and wall thickness.

For full details of our facilities and our methods of making components, write to the address below.

Pressed Steel Tank Company

Manufacturer of Hackney Products Since 1902

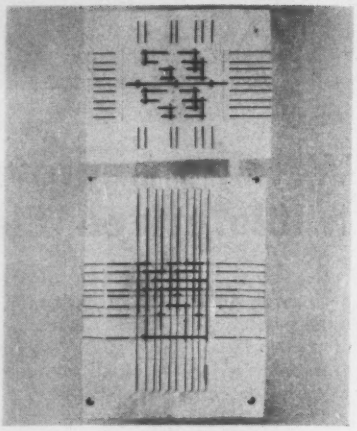
1442 S. 66th Street, Milwaukee 14, Wisconsin

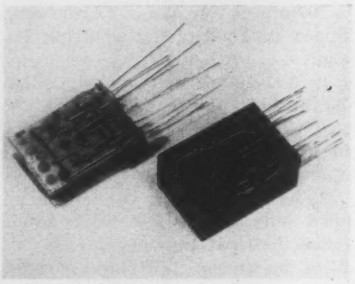
Branch offices in principal cities

Hackney

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 357



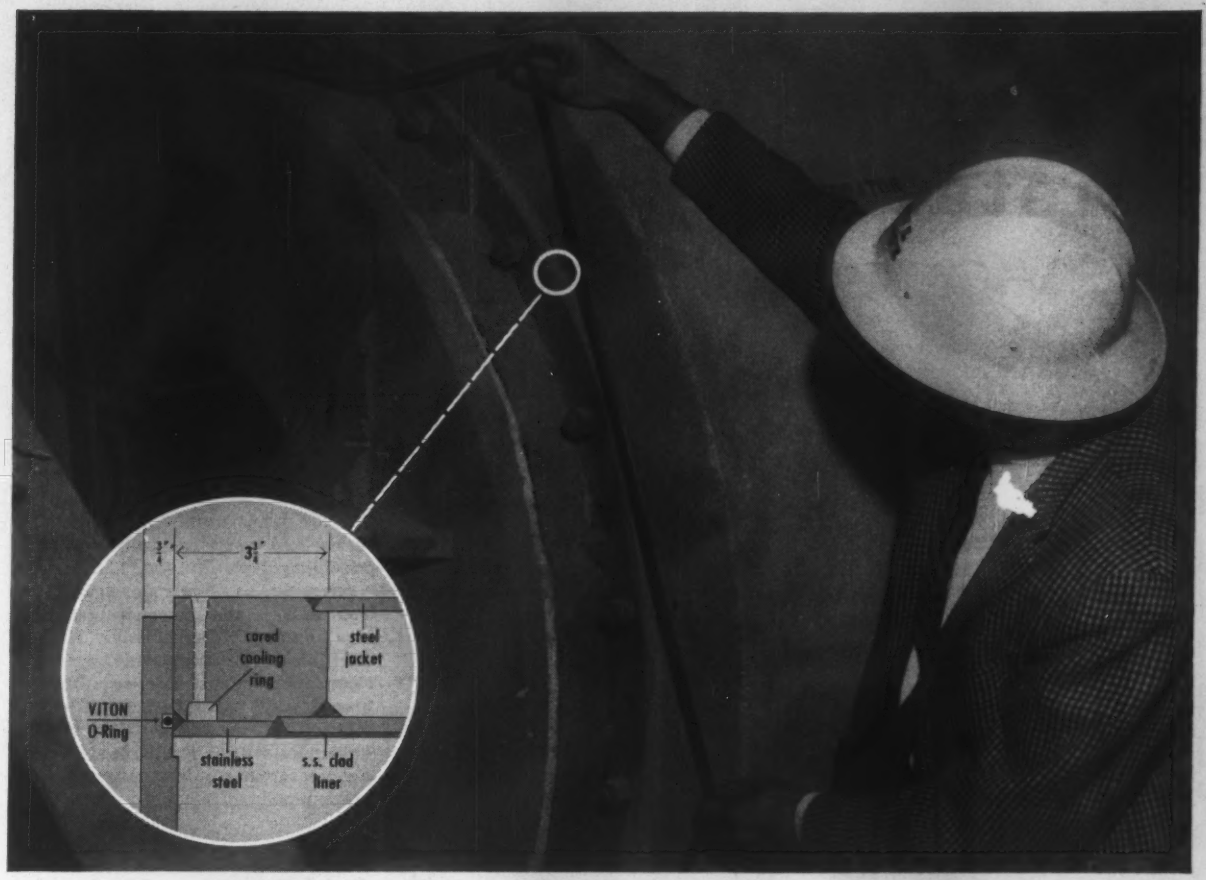


Welded wire matrices *(top) are used to interconnect components in miniaturized modules (bottom). The module on the right is encapsulated and ready for installation.*

Other symbols show where holding or anchor clips will be used. Larger holes are punched for component leads. Wherever the circuit requires a discontinuity or break, a section of wire is removed. The three layers are then assembled, grid joints welded, and the components installed and connected. Binding welds are made through certain points and the unused cross-wires trimmed to anchor the wire and film. The wire matrix also provides an orderly means of interconnecting circuit modules.

Another method that can be used is the "built-on assembly" in which components are glued together with the largest at the center and with all leads running parallel in opposite directions. This assembly gives high part density and is easy to lay out. However, it requires careful craftsmanship to produce and it is very hard to check.

A variation is prepotting the



VITON O-rings are used to seal end flanges on high-temperature chemical plant vacuum drier. Here, position is indicated by mate to seals actually used. Inset shows assembly detail.

Searing 572° F. Heat No Match for Sealing System Using VITON® O-Rings!

The problem: sealing the flanges at either end of a horizontal, agitated, high-temperature vacuum drier custom-built for a chemical plant. Heat transfer fluid in the jacket of the drier condenses at 572° F.—inches away from the end flanges. Needed was a sealing system that would work dependably—despite searing temperatures plus constant exposure to acidic reaction components.

The solution: a pair of king-size O-rings made of heat and acid resistant Du Pont VITON synthetic rubber, coupled with a cored cooling ring to help dissipate heat. The VITON flange gaskets have already been in service several hundred hours without a sign of a defect —and in this severe service, gasket deficiencies show up quickly. Based on performance to date, the VITON gaskets are expected to last the life of the equipment itself!

Learn more about VITON. In addition to acids, corrosive chemicals and heat as high as 600° F., Du Pont VITON repeatedly demonstrates its unmatched resistance to oils, fuels and solvents . . . also withstands long exposure to ozone and weathering. Ask your preferred rubber goods supplier for products of VITON for severe service applications. For complete technical data on VITON's use in O-rings, gaskets, tubing, hose and a host of other resilient parts, write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MDE-7, Wilmington 98, Delaware.

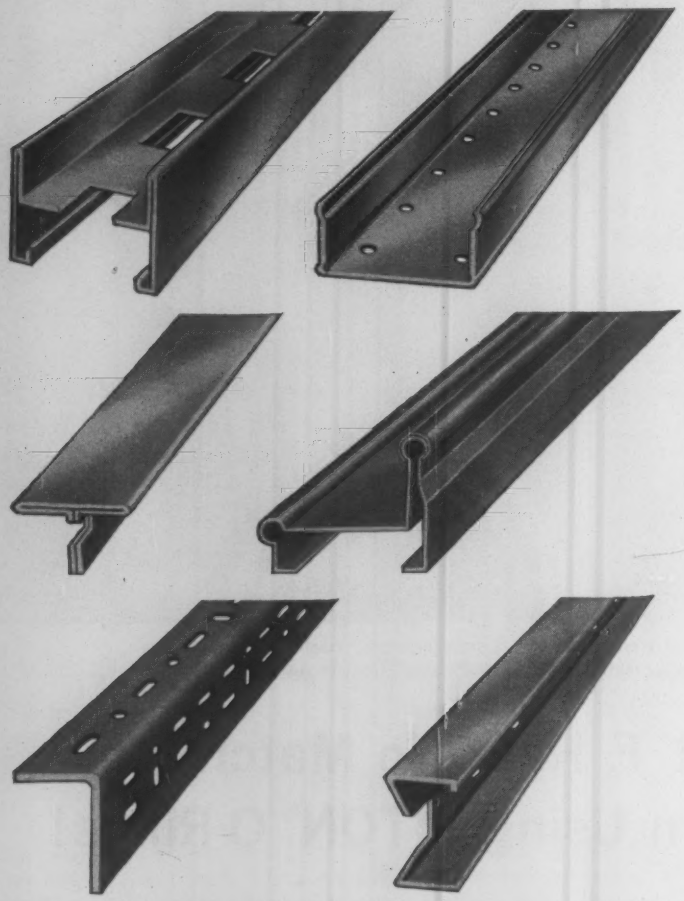
DU PONT REG. U. S. PAT. OFF.

VITON®
SYNTHETIC RUBBER

Better Things for Better Living . . . *through Chemistry*

For more information, turn to Reader Service card, circle No. 402

Engineered Metal Shapes



Roll Formed engineered shapes offer the distinct advantages of punching, notching, embossing and cutting to exact length in one continuous operation. You get the precise shape that's right for your product delivered to meet your production schedule.

Check your requirements against Roll Formed Catalog 760. It shows how good shapes help produce better products at lower cost.

SEE OUR CATALOG IN SWEET'S

ROLL FORMED PRODUCTS COMPANY

MAIN OFFICE AND PLANT
3752 OAKWOOD AVE., YOUNGSTOWN, OHIO

For more information, turn to Reader Service card, circle No. 322

assembly before welding the interconnecting leads in place.

Careful layout essential

Most of the precautions needed in welding miniaturized electronic circuits have to do with careful circuit design to prevent the welding current, particularly a.c., from passing through a transistor. This danger is least obvious, and therefore more likely, when the electrode current can loop across the junctions of two or more transistors. Circuits should be checked very carefully for this possibility.

Shorting an electrode against a lead that is not being welded can also damage components. Highly disciplined operators working from clear instructions are required to prevent this type of error. A better solution is to shield both welder electrodes with a tough, heat resistant material so that only the tips are exposed.

Acid Scrubber Made of Reinforced Polyester

An acid scrubber made from glass-reinforced, bisphenol-A polyester has been operating for six years in a highly corrosive atmosphere without repair or maintenance.

The scrubber, the last stage in a thorium extracting line, is installed in a thorium plant of Lindsay Chemical Div., American Potash Co. It is exposed to hot nitric acid and to the dilute caustic scrubbing solution.

Measuring 5 ft × 10 ft and having a ⅜-in. thick wall, the scrubber consists of three individual flanged units of reinforced plastic gasketed with polyvinyl chloride. Internal packing is also made from the glass-reinforced polyester called Atlac 382, made by Atlas Powder Co.

Ductwork also replaced

Ducts throughout the plant, made from both general-purpose polyester and stainless steel, are being replaced by lines made from the special-purpose plastic.

These conduits carry hot hydrofluoric, hydrochloric, nitric and sulfuric acids, and caustic soda. The internal corrosion problem is com-

progress through creative research in **ADHESIVES** *COATINGS . . . TREATMENTS . . .*

DESIGNER'S GUIDE TO CHEMLOK® ADHESIVES

Chemlok 220/203 . . versatile adhesive system for bonding uncured elastomers to rigid substrates.

System bonds natural rubber, SBR, butyl, neoprene and nitrile —during vulcanization—to all metals, many plastics. Uniform high-strength bonds reduce rejects. Wide manufacturing tolerances cut costs. One coat of 220 outperforms most two-coat systems; 220 over 203 gives unmatched environmental resistance. Economical, high-quality bonding has made these the most widely used rubber-to-metal adhesives. **Request Bulletin No. 2012.**

Chemlok 301 . . general-purpose structural epoxy adhesive.

This adhesive seals and fastens in one operation. It joins any combination of metal, glass, wood, fabric, ceramic, plastic, rubber and foam sponge. Removes potential leakage areas and points of stress concentration associated with mechanical fastening holes. High-strength bonds erase welding or soldering cost; permit use of lighter, cheaper materials. Chemlok 301 cures at room temperature with contact pressure, offers handling ease plus exceptional resistance to oil, chemicals, moisture and weathering. **Request Bulletin No. 3501.**

Chemlok 607 . . high-strength, high-temperature adhesive for speciality elastomers.

Adhesive bonds uncured silicone, Hypalon, Viton A, Fluorel and other speciality elastomers to metals, glass, fabrics, or plastics. Exceptional bond strength at temperatures to 500°F. improves product versatility. One-coat application saves time, equipment and expense. Chemlok 607 provides environmental resistance equivalent to the stock, unique strength/temperature ratios. **Request Bulletin No. 6005A.**

Chemlok EX-B150-1 . . .
speciality adhesive for elastomer-to-elastomer bonding during vulcanization.

EX-B150-1 forms durable, high-strength bonds between butyl, neoprene, natural, SBR and nitrile stocks. Bond flexibility permits prolonged exposure to heat and flexure without loss in dynamic properties or strength. EX-B150-1 aids in manufacture of rubber products where two or more elastomers are bonded to form a superior composite part. **Request Bulletin No. 5009.**

Chemlok EX-B579-1 . . .
RTV silicone rubber adhesive.

One-part, one-coat speciality adhesive bonds room-temperature-vulcanizing silicone rubber to metals, ceramics, glass, plastics and cured epoxy resins. Bond is formed during cure. EX-B579-1 offers processing ease with all commercially available RTV silicone rubbers, produces rubber-tearing bonds with excellent environmental resistance to broad temperature conditions. **Request Bulletin No. 6006A.**

For better bonding at lower cost, investigate Chemlok Adhesives.
Write for complete technical details and evaluation samples.

HUGHSON CHEMICAL CO.
A Division of Lord Manufacturing Co.
Erie, Pennsylvania

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HUGHSON CHEMICAL CO., Erie, Pa.
Please send me technical bulletins:

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TIN
COATING
from .00002
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Somers
THIN STRIP
For the first time tin coated thin strip is available in solderable coatings up to .0025" thick.
Pure tin and tin-lead alloys are now coated on copper, brass, or nickel in all gauges from .002 to .012 in thicknesses of .00002 to .0025.
Over 50 years experience in the highly specialized field of thin strip makes Somers your #1 source for that one job in ten that must meet rigid specifications. Write for confidential data blank to get the exact thin strip for your requirements — no obligation, of course.
SOMERS BRASS COMPANY, INC. • 94 Baldwin Ave., Waterbury, Conn.

pounded by fumes rising through the plant and attacking the outsides of equipment.

According to C. H. Angell of Corite-Reynolds Corp., fabricators and installers of the equipment, the specialty resin withstands corrosive environments better than the general-purpose polyester or stainless steel previously used.

ZK60A Forgings Not Hurt by Zr Inclusions

Segregated patches of zirconium have been found to have no effect on the fatigue strength of ZK60-magnesium alloy forgings.

According to G. R. VanDuzee, senior materials engineer, Sikorsky Aircraft Div., United Aircraft Corp., experiments have shown that the presence of segregated zirconium does not prohibit the use of strong ductile ZK60A forgings in applications where fatigue strength is critical.

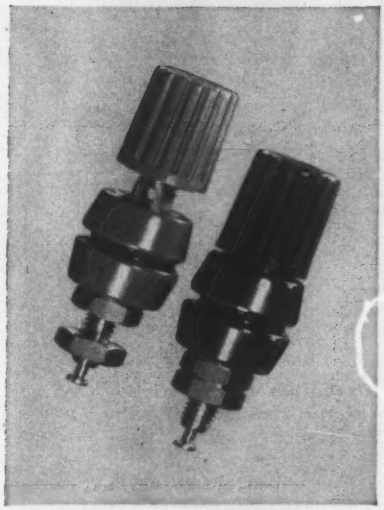
Engineers at Sikorsky Aircraft conducted a fatigue test program to

Stiffness of structural columns being tested under high pressure and temperature at Battelle Memorial Institute. In this new analytical method, the short-time, stress-strain behavior of models is used to predict the behavior of aircraft and missile structures. The equipment can apply compressive loads up to 2000 lb at temperatures up to 325 F.

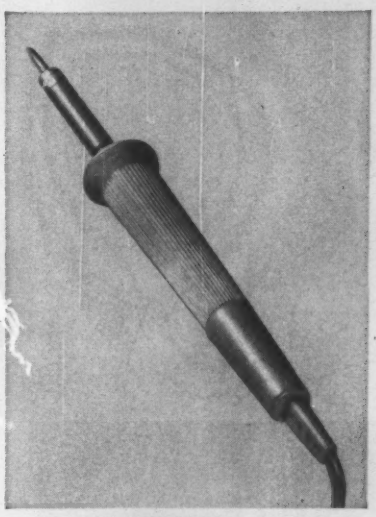
For more information, turn to Reader Service card, circle No. 389

G-E LEXAN® POLYCARBONATE RESIN

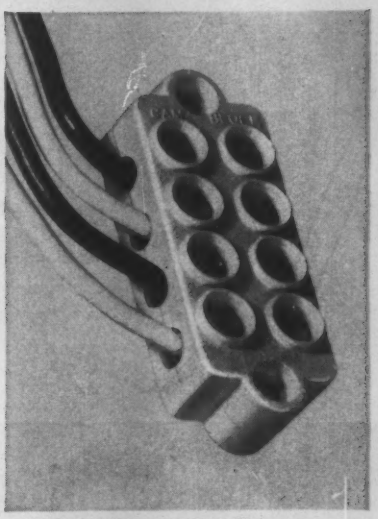
GOOD DIELECTRIC—AND MUCH MORE!



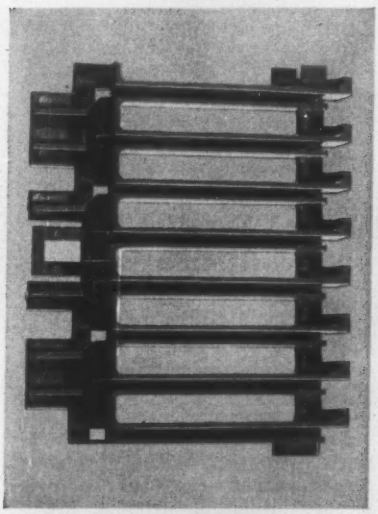
STABLE ELECTRICALS Binding posts made of LEXAN resin retain electricals even under moist, hot conditions. They do not loosen, are molded in six attractive LEXAN colors for coding. Other features are: low loss and power factor, low dielectric constant, high voltage insulation, non-sink surfaces. (Superior Electric)



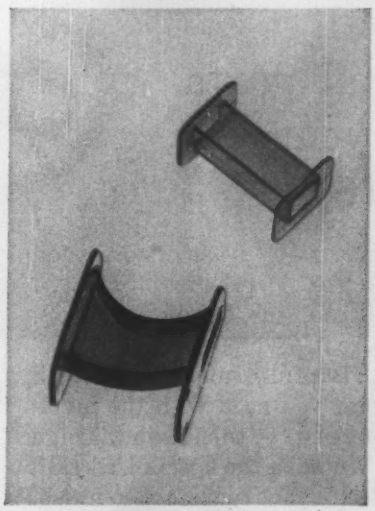
HEAT RESISTANCE Beautiful handles of LEXAN polycarbonate resin are used in rugged service on soldering irons. They resist the impact, heat and abrasion of daily bench work. The hard, glossy handles are light in weight. Molded in three pastel colors, they provide toughness and sales appeal. (Ungar Electric Tools)



SELF-EXTINGUISHING The self-extinguishing characteristic of LEXAN resin (ASTM-D635) is just one of several indispensable properties in this unique connector. Other important features are high dielectric strength, dimensional stability, moldability, good appearance, high impact strength. (Camblock Corp.)



DIMENSIONAL STABILITY Card guide for business machines is molded to close tolerances . . . must undergo minimum change in dimensions during service. Parts show excellent dimensional stability under moist and high temperature conditions. LEXAN resin meets self-extinguishing requirement. (IBM)



STRENGTH These coil forms can take temperatures above 200°F without deforming, despite stresses exerted by tightly wound wire. LEXAN resin is non-corrosive even when used with very fine Class F magnet wire. Coil forms have structural strength and stability . . . high oxidation resistance . . . stable electricals.

HIGH-PERFORMANCE DESIGNS START WITH LEXAN THERMOPLASTIC

LEXAN resin is a stable and beautiful design material. It provides an outstanding variety of top qualities — from good electricals to *the highest impact strength of any plastic.* It has excellent high-temperature properties, including a high heat distortion point under heavy loads. The material is naturally transparent . . . has often been likened to a transparent metal. In fact, it offers the production advantages of both thermoplastics and non-ferrous metals. Its other advantages are too numerous to describe here: we urge you to refer to G-E's extensive literature on LEXAN resin. Send for details on price, properties, applications and G-E's technical assistance program today! General Electric, Chemical Materials Department, Section M-71, Pittsfield, Mass.

LEXAN®
Polycarbonate Resin

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 405

are small precision metal parts ruining your appetite?

Do you look at the Chef's Special and see only small precision metal parts? Does your caviar taste like old production orders? What you're suffering from is small component indigestion . . . and Torrington is the specialist to cure it.

Manufacturing special metal parts is a full-scale business with us. We're geared to turn out whatever you need with the precision, finish, temper and hardness you need . . . turn it out at high speed at a cost surprisingly lower. We have the specialized skill and engineering experience to handle the job from start to finish.

If *you* need special parts in large quantities, don't decide anything until you've called us. Better still, send us a blueprint of the part you want. Our estimate will be prompt and accurate.

progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Connecticut

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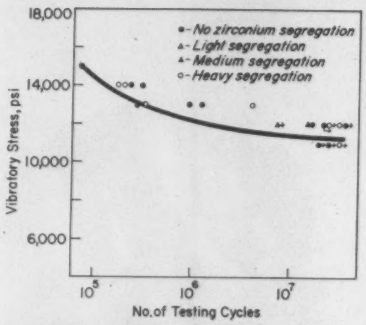


***Zirconium segregations** have no effect on fatigue strength of ZK60A magnesium forgings.*

evaluate the effects of subsurface zirconium inclusions.

Several Krause-type fatigue specimens were machined from a condition F, ZK60A hand forging containing zirconium segregates. Specimens with various concentrations of zirconium segregations in the high-stress zone were chosen for test.

Tests were performed in a flat-plate fatigue tester. Vibratory stresses were determined by strain gages located at the point of highest bending stress.

All but one specimen failed in the high stress area. Results of the tests are given in the accompanying graph. Location of the failure points shows that zirconium concentration had no influence on the specimens' fatigue strength.

Molded Plastics Reels Improve Cable Winding

Replacing steel takeup and storage reels with molded glass-reinforced polyester units is said to have solved several severe problems encountered in producing long lengths of electronic instrumentation cable.

Steel reels were formerly used exclusively in the various production processes that take the fine wire through insulating, stripping, braiding, cabling and testing. However, dented, bent and separated reel flanges frequently caused wires to break or traverse unevenly during winding or unwinding. Occasional rust and corrosion also contributed to the need for a tedious and expensive maintenance program.

The molded polyester reels are

For more information, circle No. 373

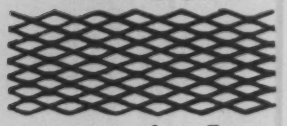
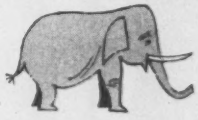
Because Spencer CARES about its customers in a special way, you can specify Spencer Plastics with special confidence. Polyethylene. Polypropylene. Nylon. We spare no effort in helping you select precisely the proper resin for the job at hand. Personalized assistance from our technical service staff is yours without charge. Product planning and marketing help, too. If you haven't already discovered what it means to have Spencer CARE behind your product, why wait? Get in touch with your nearest Spencer representative, or write us at the address below.

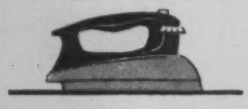
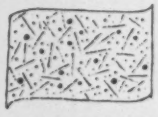
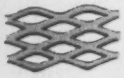
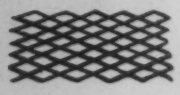
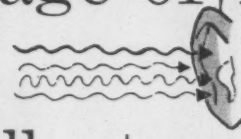
The Company Known For Its Know-How

SPENCER

"Poly-Eth"® Polyethylene • "Poly-Pro"® Polypropylene • Spencer Nylon

Spencer Chemical Company
Dwight Building, Kansas City, Mo.

With Wheeling Expanded Metal  , you can reduce product weight .....without sacrificing product strength  .

Improve product appearance as well – because Wheeling Expanded Metal comes in flattened  or textured  styles... with large openings  or small  . And this practical, decorative metal permits free passage of light , air , sound  and heat . Get the full story..... from your Wheeling man . Or write to Wheeling Corrugating Company , Wheeling, W. Va.

WHEELING CORRUGATING COMPANY • IT'S WHEELING STEEL!

Warehouses: *Boston, Buffalo, Chicago, Columbus, Detroit, Kansas City, Louisville, Martins Ferry, Minneapolis, New York, Philadelphia, Richmond, St. Louis.* Sales Offices: *Atlanta, Houston, New Orleans.*

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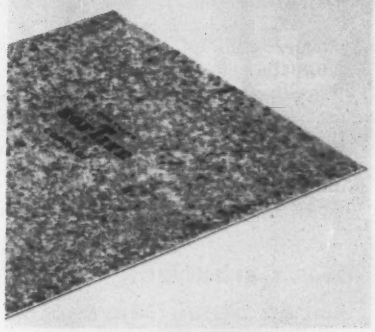
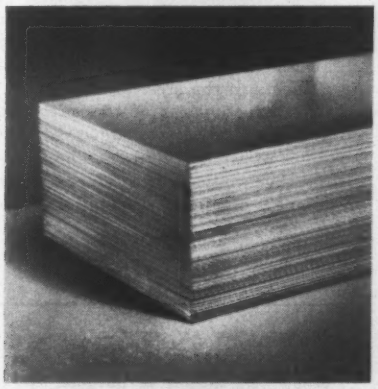
OTHER WHEELING PRODUCTS



Wheeling SofTite® Cop-R-Loy® Galvanized Sheets offer outstanding corrosion protection . . . can be painted . . . and formed into any shape specified.

Wheeling Hot and Cold Rolled Sheets are widely known for their smooth, uniform finish. Hot and Cold Rolled Strip also available.



Wheeling Long Terne is available in widths to 48". It is normally supplied with either commercial or special terne coatings.

MATERIALS ENGINEERING & DESIGN

said not to dent during normal rough handling and storage, nor do they rust, corrode, or short under electrical tests. They weigh one-third less than their steel counterparts, and the flanges do not separate from the drums.

The new reels, developed and molded in matched metal dies by Molded Glass Tray Co., Linesville, Pa., are being supplied with 10-in. long drums and 10-in. and 24-in. dia flanges.

Steel Powder Parts Position Camera Lens

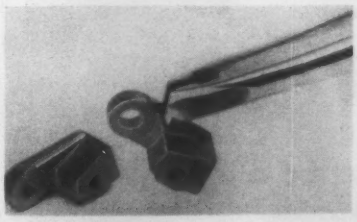
Two tiny "jammers" made from powdered stainless steel automatically lock the lens and shutter unit in position when the new Polaroid camera is opened.

Type 316 stainless steel was specified because the two jammers, less than ⅜ in. long, must have high strength and unusual corrosion resistance. These requirements posed a difficult production problem: stainless is hard to machine and it would be prohibitively expensive to otherwise produce the small, complex part within precise tolerances.

Jammers small, intricate

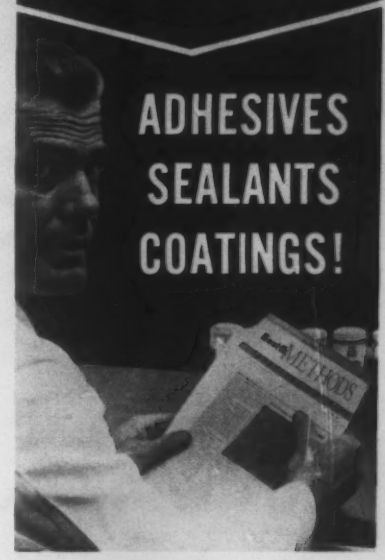
The two bearing holes in each part, for example, must be uniformly concentric and perpendicular to mating flats within 0.002 in. TIR. Also, several corners must be formed as sharply as possible.

The Polaroid jammers are produced by Dixon Sintaloy Inc., Stamford, Conn. After the steel powder is sintered close to the specified dimensions it is coined to bring each



***Small jammer** locks a camera's lens and shutter assembly into position. The two used in each camera are sintered from powdered stainless steel.*

NEW GUIDE TO ADHESIVES SEALANTS COATINGS!



From the laboratory, from experience, from applications, from testing . . . the makers of Bostik adhesives, coatings and sealants have assembled a wealth of information that could be vital to your operations.

Over fifty years' experience lies behind the development and application of a wide range of adhesives and related products. Challenging problems are being continually solved in the Bostik laboratories, and technical specialists are meeting with users daily to help them select a Bostik adhesive that will bond their product better.

Now through the new Bostik METHODS you can tap this wealth of information. Bostik METHODS will keep you posted on the dynamics now taking place in adhesives, sealants and coatings.

For your copy of Bostik METHODS, send us your name and address, and you'll receive the first issue by return mail. You'll find it will pay off handsomely in new ideas, cost savings, and application know-how. Bostik Dept. B B Chemical Company, Division of United Shoe Machinery Corporation, 784 Memorial Drive, Cambridge 39, Massachusetts.

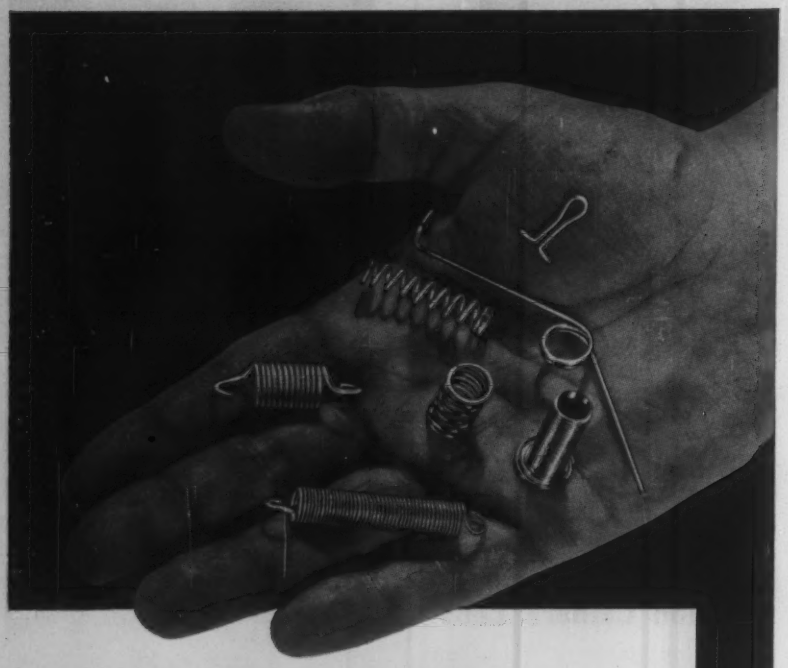
Bostik*

ADHEREABILITY

THE SKILL OF MAKING THINGS STICK

*Bostik is the registered trademark of B. B. Chemical Company for adhesives, sealants and coatings.

For more information, circle No. 438



CUT WIRE COSTS UP TO 60%!
...with Page Special HB

If you are now using music wire, or if you have been prevented from using it because of its high cost, it makes good sense to investigate PAGE *Special* HB. In every case, the tensile strengths of *Special* HB approach those of music wire—and in sizes .090" and coarser equals them! Moreover, *Special* HB costs as much as 60% less than music wire.

A hard-drawn, high-carbon steel wire, *Special* HB is available in galvanized or bright finishes and in diameters from .020" to .162". We'll be glad to send you the full story, including a detailed comparison of tensile strengths.

As America's leading special-purpose wire mill, PAGE can supply a wide variety of manufacturers wire items with just the tensile strength, ductility, finish and other properties you need. Tell us your requirements—we'll recommend a PAGE wire to help you reduce costs and improve your product.

Write us at Monessen, Pa., for Booklet **DH-107** on *Special* HB—or for information on what PAGE has to offer to meet your other wire requirements.

PAGE

ACCO —*the source for answers to wire problems*

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AMERICAN CHAIN & CABLE COMPANY, INC.
Monessen, Pa., Atlanta, Chicago (Melrose Park), Denver, Detroit, Houston, Los Angeles, New York, Philadelphia, Portland, Ore., San Francisco, Bridgeport, Conn.

For more information, turn to Reader Service card, circle No. 424

part within the allowable tolerances. For example, the thickness of the jammer pads is controlled within ±0.001 in.

Because only two die cavities are used, one for the left and the other for the right jammer, all corresponding jammers are identical and interchangeable.

Gas Carburizing For Large Steel Gears

Gas carburizing successfully surface hardens several alloy steels for use in large gears, according to a report by W. Simon of Westinghouse Electric Corp.'s Materials Engineering Depts.

In his report, Mr. Simon notes that AISI 3310, 4617, 8620 and 9310 alloy steels can be gas carburized successfully. Hardening large gears, such as those used in marine engines, will improve their strength and service life.

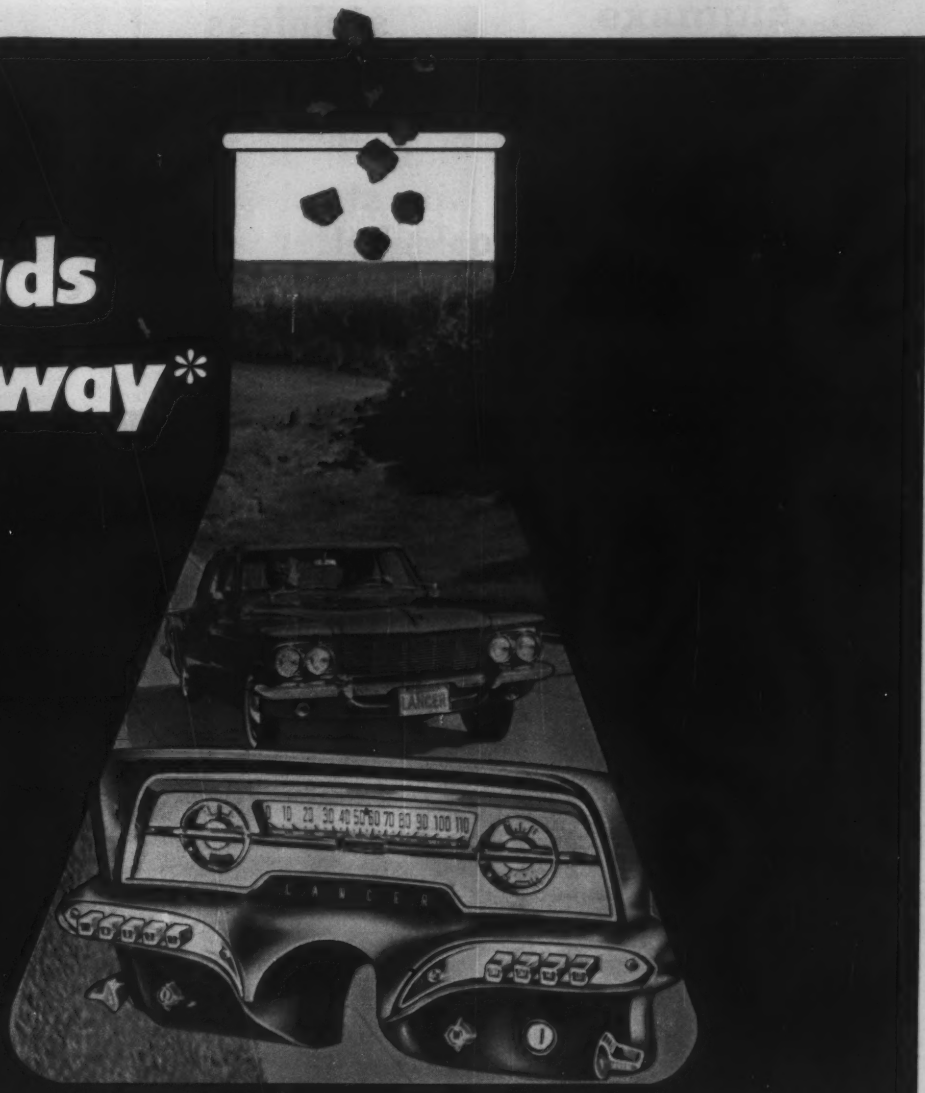
In an experimental program, specimens of each of the four steel alloys were carburized for 8 hr at 1650 F in an Endogas atmosphere enriched with methane, then oil quenched from 1550 F to attain a minimum Rockwell surface hardness of C60 and a Rockwell case hardness of C50 at a depth of 0.050 in.

The minimum amount of enrichment gas necessary to achieve these hardnesses is about 11% by volume. Too much methane contributes excess carbon and consequent retention of austenite in the surface of the steels. Inefficient oil quenching also results in excessive austenite and consequent soft spots in the steels.

The effectiveness of the carburizing technique was judged by the results of surface and case hardness tests, by analysis of surface carbon content, and by metallographic studies.

DON'T MISS AN ISSUE — Changing your address? If so, please let us know two months in advance. We will do our best to see that you don't miss an issue. Be sure to include your new postal zone number.

it leads the way*



Lancer Instrument Cluster molded by Kent Plastics — Evansville, Ind.

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TOUGH, HARD, RIGID POLYMERS FROM BORG-WARNER

It's another great one from Dodge . . . the Lancer Compact. And no wonder. Just look at this style-trimmed instrument panel cluster molded of CYCOLAC brand ABS polymers. Pounds lighter than metal, it's strong and tough, will never rust, stain or tarnish. Warm and smooth to the touch, molded parts of this ABS material remain new-looking for the life of the car. Economical, too . . . a cluster can easily be produced in intricate shapes and vacuum metalized without difficulty. Installation is fast, simple. No marring or scarring; little post-installation finishing required. And CYCOLAC brand polymers are colorable too . . . to exactly match-meet the myriad of automotive finishes. Proof again that this Borg-Warner material is the most versatile of all plastics. Investigate . . . for full details write Dept. L-7.

MARBON CHEMICAL MARBON B-W CHEMICAL DIVISION **BORG-WARNER**

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stainless steel adds sales appeal. the car designed with stainless steel looks better when you buy it and is worth more when you sell it.

McLOUTH STAINLESS STEEL

McLouth Steel Corporation · Detroit 17, Michigan

Look for the **STEELMARK** on the products you buy

For more information, turn to Reader Service card, circle No. 332

(cont'd from p 15)

What's new IN MATERIALS

Multicolored Vinyl Coatings

Two-step spray process applies finishes that are tough, decorative

■ Vinyl coatings, previously available only in solid colors, can now be applied in unlimited color combinations and with controlled texture.

The finishes were developed by Coatings Div., Metal & Thermit Corp., Rahway, N. J. They can be applied to either phosphated steel or aluminum by conventional or electrostatic spraying techniques.

The two-step process: Apply a wet film base of the undertone color in three or four spray passes. Immediately afterwards, while the part is still wet, apply the topcoat in three or four spray passes.

To get different colors and textures, change the vinyl material. You can also vary texture by closely controlling viscosity and wetness.

Color texture quickly begins to form during topcoat application and continues to form during the specified 15 to 30 min flash-off period. Following flash-off the coatings are baked for 5 min at 200 to 250 F and then for 15 min at 300 to 325 F. If necessary, reject parts can be stripped and resprayed. KEY NO. 609

***Multicolor coating** is applied by depositing three or four passes of ground coat and covering it, while wet, with three or four passes of topcoat.*

Tungsten Tool and Die Steel

A newly developed tungsten tool and die steel is said to have longer service life than conventional high carbon, high chromium tool and die steels. A plunger made of the new steel and used in a die to compact powdered metals lasted four times longer than a tool made from a standard high carbon, high chromium steel.

The new steel, known as Hi Wear 64, is marketed by Carpenter Steel Co., 101 W. Bern St., Reading, Pa.

COMPOSITION OF HI WEAR 64 (%)

Carbon	1.50
Manganese	2.00
Silicon	0.25
Chromium	0.90
Molybdenum	1.00
Tungsten	4.00

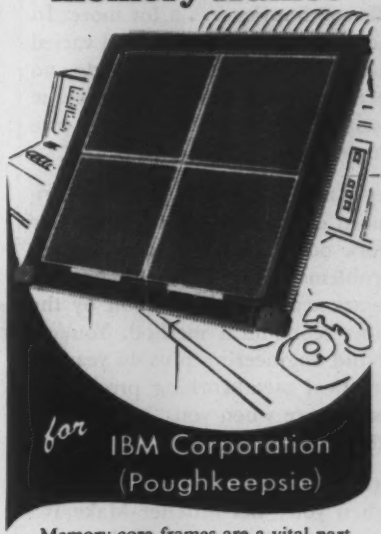
Low hardening temperature

The producer says intricate shapes of the tool steel up to 2 in. in dia can be air hardened from 1550 F, compared to air hardening high carbon, high chromium steels which require heat treatment from 1800 F. The relatively low hardening temperature of the steel is said to offer

example...

FIBERITE

at work in computer memory frames



Memory-core frames are a vital part of IBM's fabulous computers.

These frames hold and protect the tiny "memory units" which store information for processing.

IBM Poughkeepsie, working with Fiberite Corporation, specified a reinforced plastic frame material with these characteristics:

- The ultimate in dimensional stability under widely varying atmospheric conditions
- High impact and flexural strength
- Minimum shrinkage values
- High dielectric strength
- High heat resistance
- Good molding characteristics
- Automatically preformable

With Fiberite compound F.M. 4005, the exact formulation was achieved through the intense cooperation of Fiberite research engineers and their counterparts at IBM. Results have been called "outstanding."

Your firm, too, can benefit from Fiberite's experience, skill and imagination. Special applications to fit special problems are Fiberite's stock-in-trade.

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Mueller Brass Co. of Port Huron is much more diversified than the name "Brass" implies . . . a lot more. In fact, because of its many and varied facilities . . . its *men, methods* and *metals* . . . Mueller is in the unique position of being able to offer true single source service.

MUELLER HAS THE MEN . . . experienced engineers with the ability to work out, creatively, tough design problems, and improve a part or components for production by the most economical method. You get sound engineering plus 44 years of practical metalworking production experience when you "Let Mueller Make It."

MUELLER HAS THE METHODS . . . when you "Let Mueller Make It", you are utilizing one single source that is able to produce parts any one of these ways: as forgings, impact extrusions, sintered metal parts, screw machine products, formed tube or as castings.

MUELLER HAS THE METALS . . . and the materials . . . to produce precision parts in aluminum, brass, bronze, copper, iron, and steel in hundreds of different alloys to meet each exact requirement.

In addition, Mueller Brass Co. has complete and modern facilities for performing all types of finishing and sub-assembly operations. Another plus value is nation-wide sales engineering service.

So, in the final analysis, no matter where you fit in the American industrial picture, whether you're making missiles or mowers...and no matter where you're located, it will pay you to LET MUELLER MAKE IT!

MUELLER BRASS CO.
PORT HURON 21, MICHIGAN

maximum protection against the dangers of decarburization, distortion and surface damage.

The steel through-hardens in sections up to 6 in. when oil quenched from 1450 F.

The new grade is described as nondeforming, with minimum size change occurring after tempering at 300-400 F. For example, a 1-in. thick piece air treated from 1600 F will expand about 0.001 in. when hardened. But it will return to within 0.005 in. of its original length when tempered at 300-400 F.

Potential uses

The new steel is recommended for all kinds of punches and dies including draw dies, lamination dies and blanking dies. It is said to be an excellent material for tools to blank and form abrasive materials, phosphor bronze and nickel strip. The grade is also suitable for mold plates used in making refractory materials, and for feed rolls handling abrasive materials such as hot rolled products with poor surface condition and scale.

The producer says the steel is not designed for red hardness, and therefore should not be used for applications where service temperatures exceed 350 F.

Noted briefly in our May issue.

KEY NO. 610

Silicone Rubber Bonds to Unprimed Surfaces

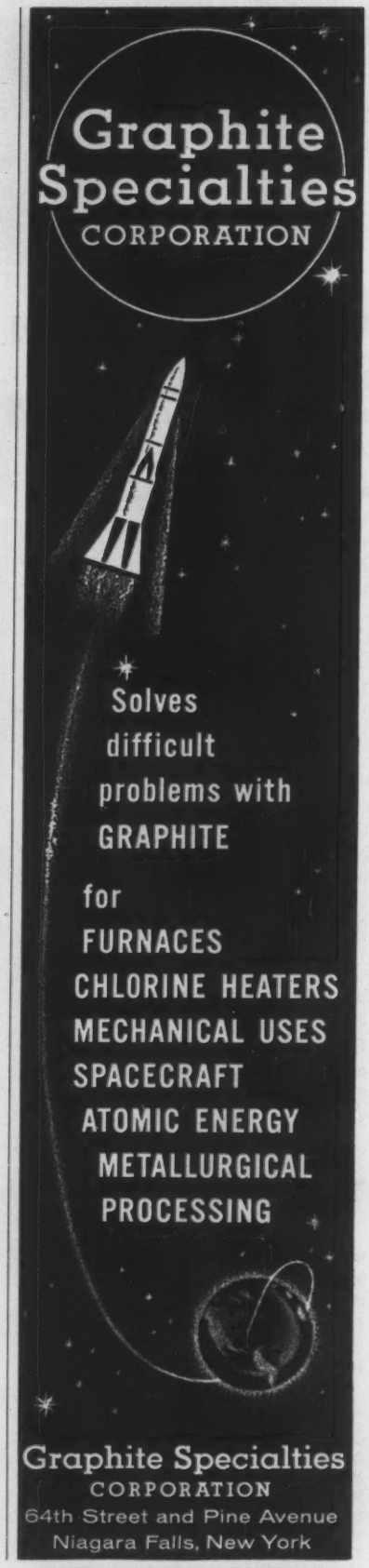
An extreme-low-temperature compound is the first of a new family of self-bonding silicone rubber compounds and reinforced gums that can be bonded to unprimed ferrous metals. The bond that is formed is generally stronger than the high strength rubber itself (see photo).

The new self-bonding grade of silicone rubber establishes a bond through direct reaction with metal

PROPERTIES OF SE-5504U RUBBER*

Tensile Strength, psi	1500
Elongation, %	550
Tear Strength, lb/in.	200
Durometer Hardness	A50
Compr Set (Method B, 22 hr at 300 F), %	45

*Oven cured 25 hr at 350 F.

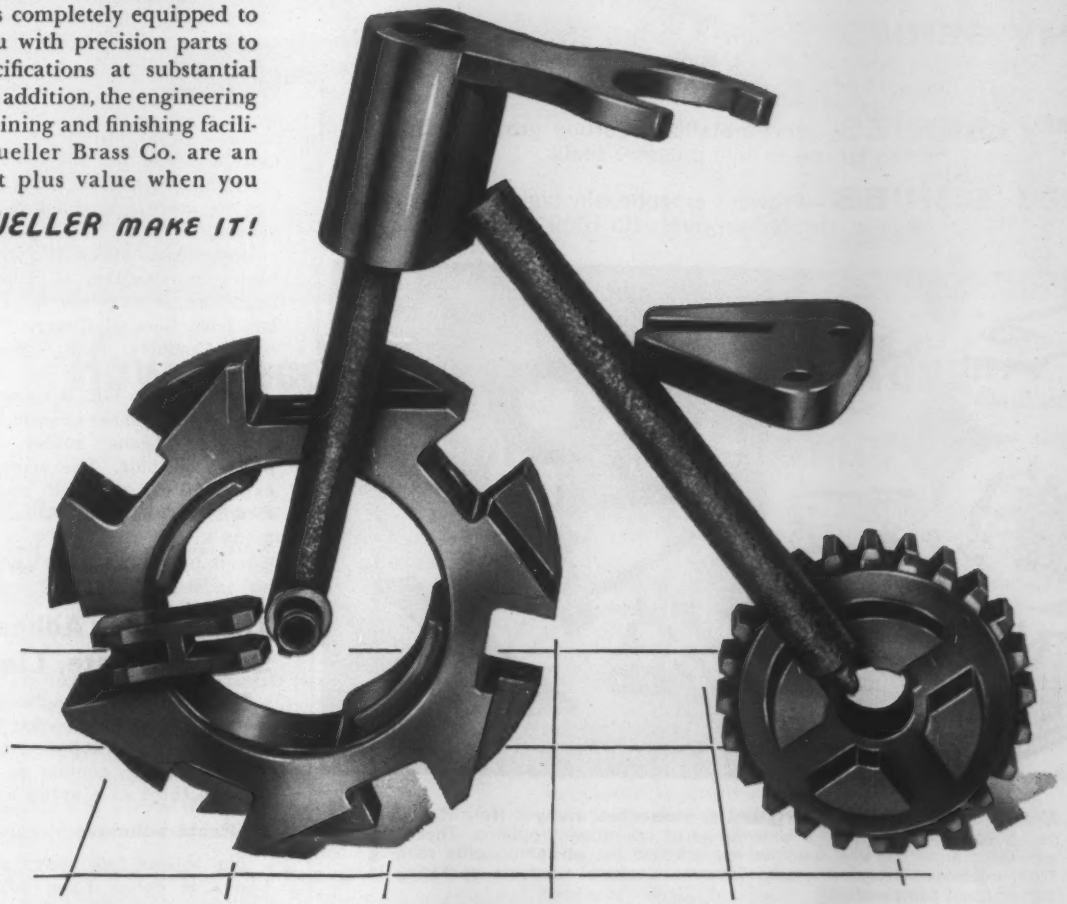


For more information, circle No. 404

MUELLER CAN MAKE MOST ANYTHING IN SINTERED METAL PRODUCTS...

Sintered metal gears, cams, special purpose filters and structural members from iron, nickel, stainless steel, brass and copper alloys are produced by Mueller for practically every segment of American industry. Whatever your product requirements are, the Mueller Sintered Metal Products Division is completely equipped to supply you with precision parts to exact specifications at substantial savings. In addition, the engineering staff, machining and finishing facilities of Mueller Brass Co. are an important plus value when you

LET MUELLER MAKE IT!



MUELLER BRASS CO.

PORT HURON 21, MICHIGAN

339

For more information, turn to Reader Service card, circle No. 360

Use this **designers' check-list** for

MORGANITE
FINE CARBON
GRAPHITES

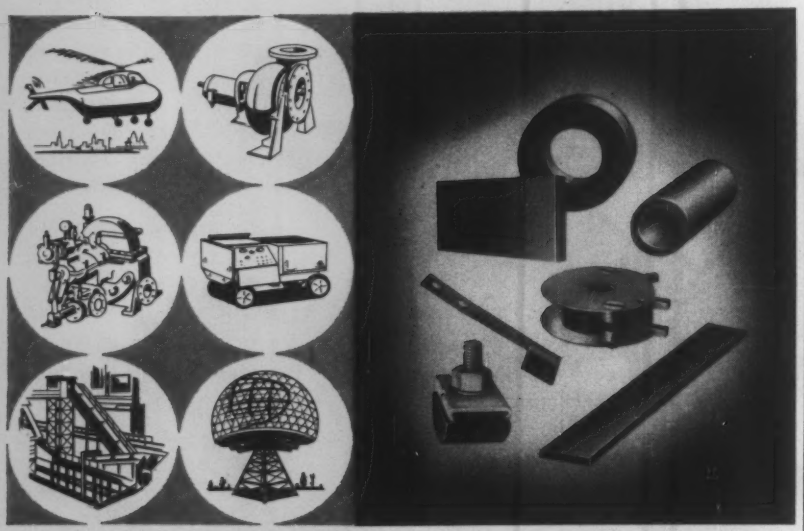
Performance-proven Grades to Solve
a Wide Range of Design Problems

CY SERIES—Plain carbon graphite. Excellent for bearings, vanes, valves and other mechanical components.

MY SERIES—Metallized carbon graphite. Provides extra-long life in difficult applications wherein operating conditions are severe.

PY SERIES—Non-metallized carbon graphite. Specially treated for use in high pressure seals.

EY SERIES—Provides exceptionally high-reliability in the presence of high temperatures (to 1000° F).



Self-lubricating Morganite possesses many different advantages capable of solving a wide range of operating problems. These dependable materials are specified for a broad list of components ranging from bearings in sealed mechanisms to electrical contacts operating in extremes of temperature.

Call or write for literature or recommendations on specific applications. Morganite sales engineers will be happy to explain the advantages of Morganite for use on original equipment or as replacement parts in your maintenance projects.

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For more information, turn to Reader Service card, circle No. 330

What's new IN MATERIALS

***Rubber compound** was stretched to approximately five times its original size under direct pulling stress and slowly ruptured. Bond remained intact.*

surfaces; conventional silicones require a primer to achieve a chemical interaction between the elastomer and the surface to which it is to be bonded.

Designated SE-5504U, the compound is available in commercial quantities at $5.20 per lb in 1000-lb lots from General Electric Co., Silicone Products Dept., Waterford, N. Y.

According to GE, the new rubber will cut the number of steps involved in the silicone rubber bonding process in half. The compound is expected to be used for shock mounts, oil seals and rolls.

Noted briefly in our April issue.

KEY NO. 611

Three Epoxy Adhesives Sold as Paste, Liquids

Three new epoxy adhesives have been placed on the market recently. One adhesive is supplied as a solvent-free paste, another as a liquid, and the third as a syrup or jelly.

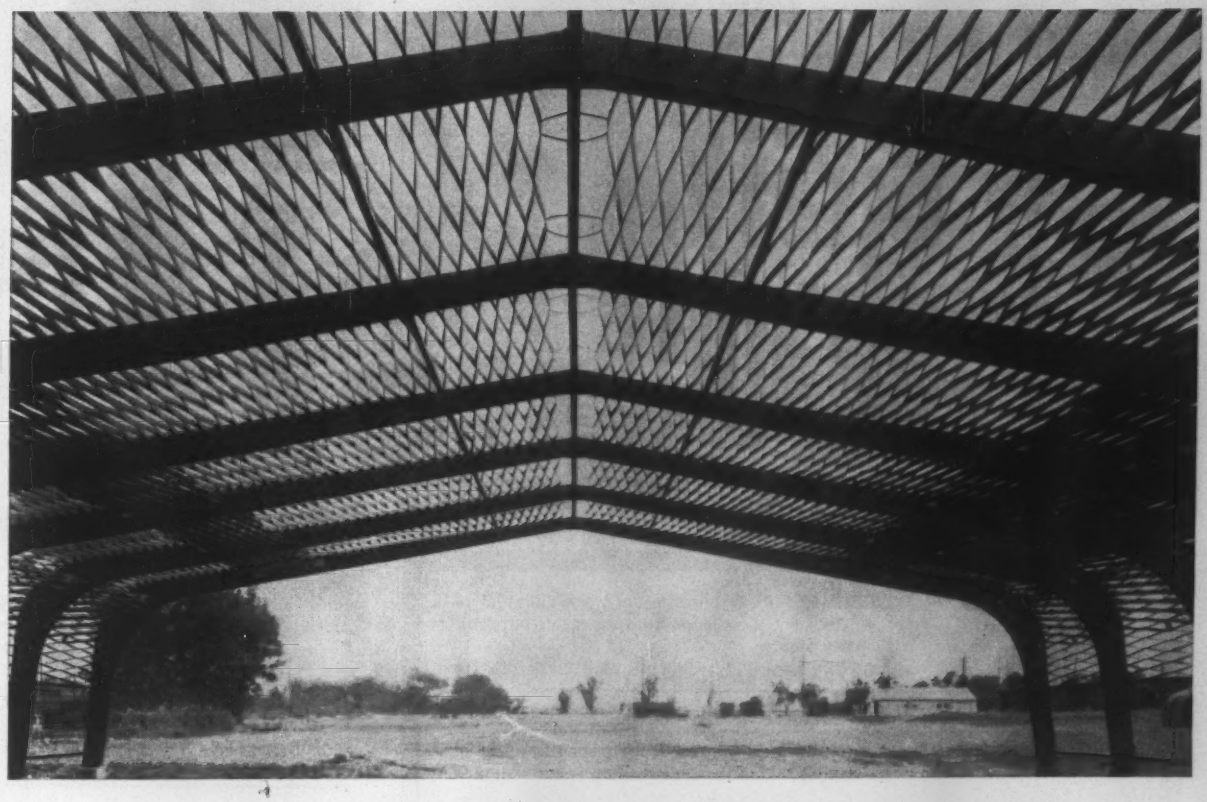
1. Paste adhesive

The solvent-free epoxy paste adhesive is called Epon 901 and is available from Shell Chemical Co.'s Adhesives Dept., P. O. Box 831, Pittsburgh, Calif.

Shell says the adhesive can be cured with four different curing agents that offer cure conditions from room temperature to 300 F.

A gives the adhesive a pot life of 2 hr at 75 F and a cured service temperature range up to 225 F. Recommended cure is 2 hr at 200 F.

continued on p 144



How wood engineering helps improve lightweight roofing performance

NEEDED: a supporting structure for roof covering that could take maximum advantage of modern, lightweight roofing materials. Plastic, plastic-and-fiberglass, pressed fiber products, textiles, plywood, and light metals serve best as roofing only if supported *continuously* by the structure.

To meet this need, Gamble Brothers developed the Gambella — a lamella-type structure which provides, in effect, an expanded purlin (beam) which distributes roof loads uniformly to the framing members. This uniform loading makes possible the use of framing members of smaller dimension for equivalent loads.

Problems like this are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

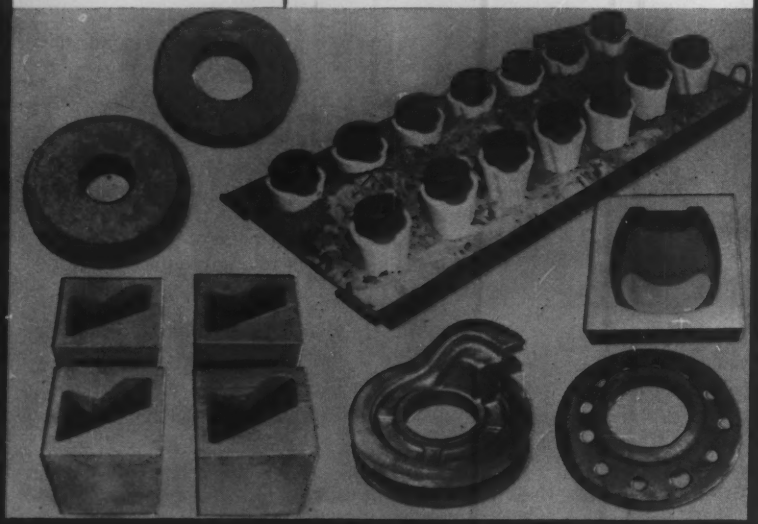
For more information, turn to Reader Service card, circle No. 338

NOW VANADIUM-ALLOYS TOOL AND SPECIAL STEELS

cast to shape

TO YOUR PARTICULAR REQUIREMENTS

STANDARD GRADES	**FORMEX**—a 5% chrome hot work die steel **AIREX**—a 5% chrome cold work, air hardening die steel **CROMEX**—a 12% chrome cold work die steel
SPECIAL COMPOSITIONS	Available to customer specifications
TYPICAL APPLICATIONS	Forming rolls, cams, drop forge trimming die, forming or blanking dies, molds, draw rings



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VANADIUM-ALLOYS STEEL COMPANY

LATROBE, PENNSYLVANIA

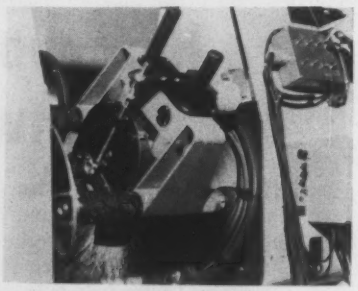
For more information, turn to Reader Service card, circle No. 356

What's new IN MATERIALS

B-1 gives a pot life of 50 min at 75 F and a service temperature range up to 225 F. The adhesive can be cured at temperatures ranging from 75 to 250 F.

B-2 gives a pot life of 30 min at 75 F. Service temperature range is up to 225 F. Recommended cure; 2 hr at 200 F. When bonded to aluminum, the adhesive has a shear strength of 3000 psi at —67 F, 2600 at 220 F, and 950 at 260 F.

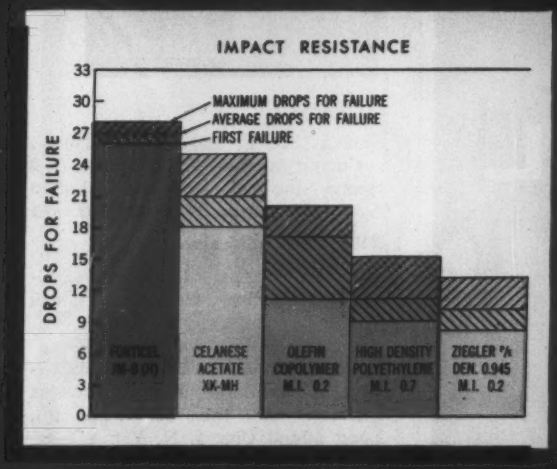
B-3 gives a pot life of 6 hr at 75 F. Service temperature range is up to 350 F. Recommended cure: 30 min at 240 F plus 90 min at 350 F. Shell says that Epon 901 combined with B-3 meets the requirements of MIL-A-8431, Type I, Class B for bonding aluminum. Typical shear strengths for bonds to etched aluminum are 3100 psi at —67 F,

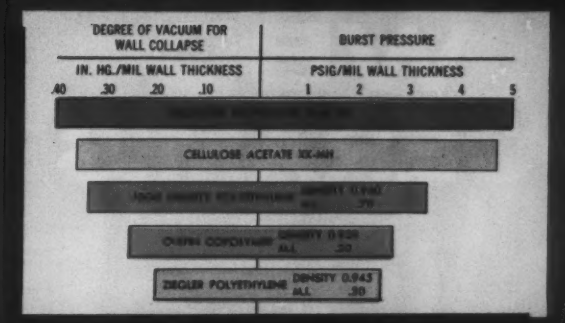


Automatic pipe line welding—A new process that makes automatic pipe line welding in the field a reality for the first time has been developed by Esso Research and Engineering Co., 15 W. 51st St., New York 19. Battelle Memorial Inst. and Air Reduction Sales Co. worked with Esso in developing the process.

Key to the method is an arc welding device (shown above) that clamps over and welds two lengths of pipe twenty times faster than possible with present hand welding techniques. When the arc welder is in position over pipe ends, it firmly clamps in place with dual prongs. An air driven abrasive cutting wheel then slices a tiny sliver from each of the pipe ends. The arc welder follows in the track of the cutter and performs the weld. **KEY NO. 612**

CELANESE POLYMER COMPANY




DEGREE OF VACUUM FOR WALL COLLAPSE
IN. HG./MIL WALL THICKNESS
.40 .30 .20 .10
BURST PRESSURE
PSIG/MIL WALL THICKNESS
1 2 3 4 5
CELLULOSE ACETATE XX-MH
ZIEGLER POLYETHYLENE DENSITY 0.945 M.I. .30

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Only Cellulosics offer toughness and transparency with economy

New blow molding techniques, new cellulosic materials can mean improved products and lower costs for you. And you can depend on Celanese for the newest and best in cellulosics!

Bottles, for example, blow-molded of Celanese cellulosics are light in weight . . . economical . . . far stronger and impact-resistant than similar bottles of many polyethylenes. And they will hold many products polyethylene can't. Proof? Refer to the charts on this page. And specific formulations can be had with either FDA or Underwriters approval.

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Don't *you* overlook the tried and true advantages of cellulosics—for various uses from bottles to industrial components. Only cellulosics offer you both toughness and transparency at a reasonable price. Celanese® Forticel®

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For more information, circle No. 437

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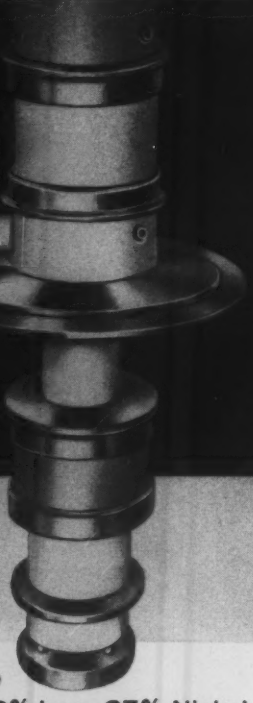
...from -75° to +600° C!



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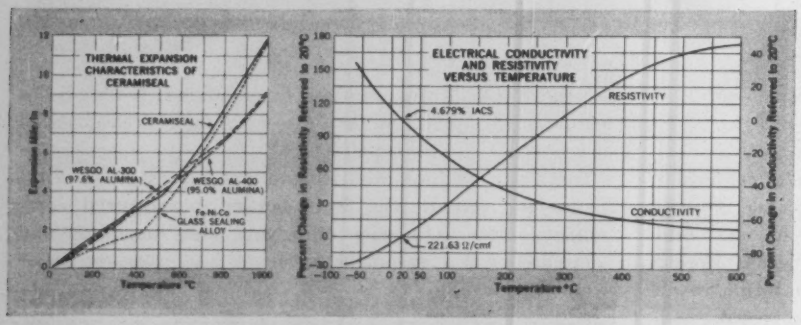
CERAMISEAL (U. S. Pat. No. 2,960,402)

Chemical Analysis: 25% Cobalt, 48% Iron, 27% Nickel

Specially designed by WBD for ceramic-to-metal sealing, CERAMISEAL alloy has expansion characteristics closely matching those of high temperature alumina ceramics. Low thermal conductivity, approximating that of ceramics, minimizes thermal stresses during rapid heating and cooling cycles. CERAMISEAL is readily brazed, deep drawn and machined; is supplied (air or vacuum melted) in wire or strip.



Call or write for Ceramiseal Bulletin and information on other WBD Sealing Alloys.

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In Canada: Canadian Wilbur B. Driver Co., Ltd., 50 Ronson Drive, Rexdale (Toronto)

PRECISION RESISTANCE, ELECTRONIC AND MECHANICAL ALLOYS FOR ALL REQUIREMENTS

For more information, turn to Reader Service card, circle No. 346

What's new IN MATERIALS

3000 at 300 F, and 1200 at 350 F.

Curing agents A, B-1 and B-2 change the color of the adhesive from gray to red. **KEY NO. 613**

2. Liquid adhesive

A new, two-part liquid epoxy adhesive gives clear, transparent bonds and is particularly useful for bonding glass and ceramic parts. Designated Rez-N-Glue EP-F, the adhesive is available from Schwartz Chemical Co., Inc., 50-01 2nd St., Long Island City 1, N. Y.

The developer says the adhesive should be used within 20 min after mixing with the curing agent.

KEY NO. 614

3. Syrup adhesive

A fast-curing epoxy adhesive is sold as a syrup and as a petrolatum-like jelly for ease of application in a number of products.

The adhesive, called Mereco X-305, is available from Mereco Products Div., Metachem Resins Corp., 530 Wellington Ave., Cranston 10, R. I.

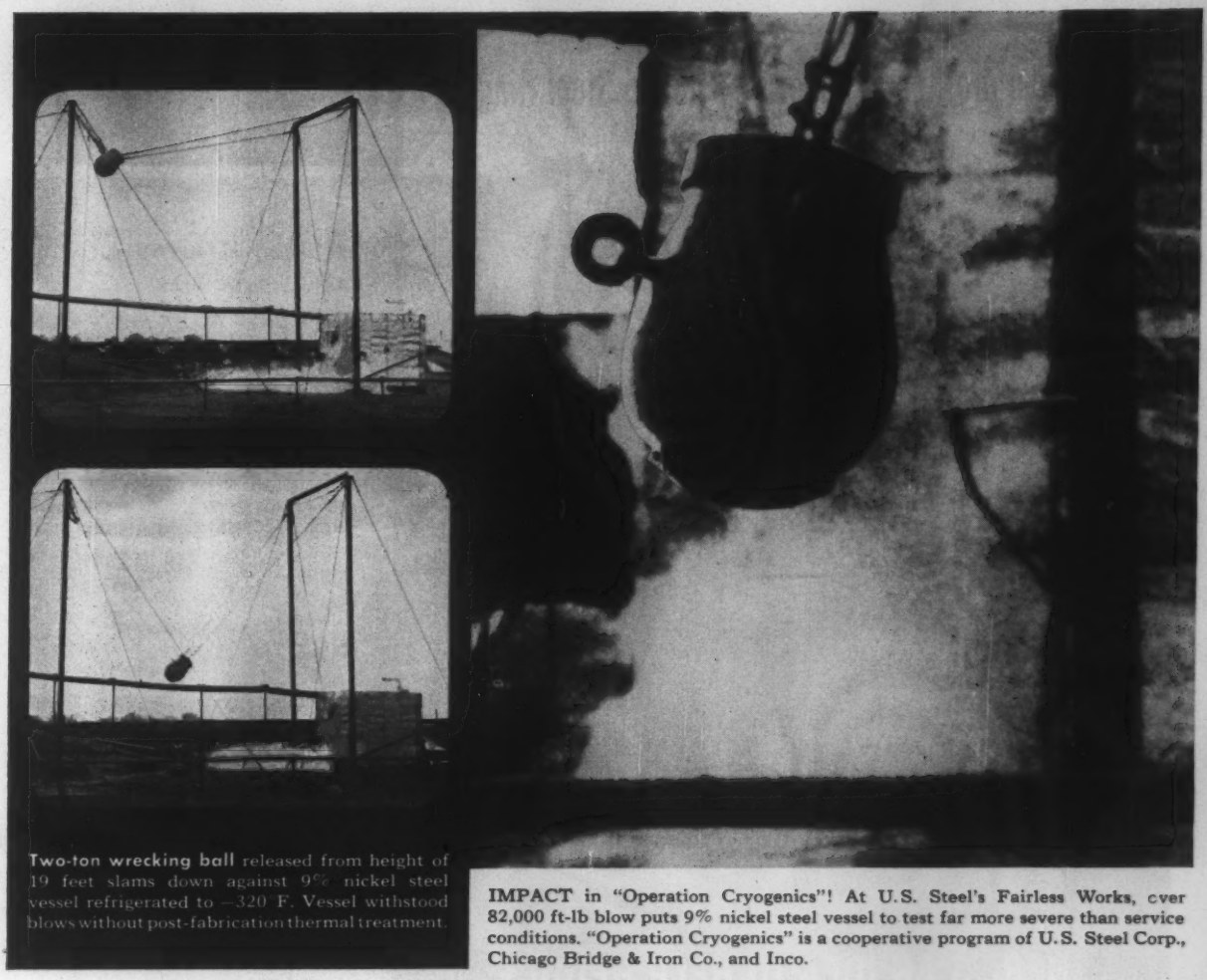
One part curing agent added to two parts adhesive sets the adhesive in 45 sec without fuming. The two-part epoxy adhesive is expected to be used for joining electronic and other parts. **KEY NO. 615**

Cold Extrusion Cuts Cost of Titanium Parts

Low cost manufacture of titanium fittings has apparently been made possible with precision cold extrusion techniques developed by P. D. Frost, R. J. Fiorentino and A. M. Sabroff of Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.

In a pilot run, full-size hexagonal cups were backward extruded in a single operation from solid cylindrical AMS 4902 unalloyed titanium billets 1 in. in dia by ⅝ in. thick. The operation involved a 55% extrusion reduction and required a pressure of about 335,000 psi. The hexagonal cups, measuring 1 in. across the flats by 1 in. long, with 25/32 in. bore, were finish machined and threaded on a screw machine.

The titanium billets used in the cold extrusion technique are half the weight of those needed for screw machining and are cut from round



Two-ton wrecking ball released from height of 19 feet slams down against 9% nickel steel vessel refrigerated to −320 F. Vessel withstood blows without post-fabrication thermal treatment.

IMPACT in "Operation Cryogenics"! At U.S. Steel's Fairless Works, over 82,000 ft-lb blow puts 9% nickel steel vessel to test far more severe than service conditions. "Operation Cryogenics" is a cooperative program of U.S. Steel Corp., Chicago Bridge & Iron Co., and Inco.

9% Nickel steel wins giant hammer test at −320°F

"Operation Cryogenics" proves 9% Nickel steel vessels need no thermal treatment after welding

Imagine the tremendous impact when this two-ton wrecking ball swings down through a long arc and smashes against the steel tank!

Certainly brutal punishment at ordinary temperatures . . .

But in this test the tank was filled with liquid nitrogen and held *at 320 degrees below zero Fahrenheit.*

At this ultra-cold temperature, many materials become brittle and shatter under impact. But steel containing 9% nickel remains tough and ductile. In fact, the yield and tensile strengths of 9% nickel steel actually *increase substantially* as temperature is lowered.

In test after test, the pressure vessels —not thermally treated after welding— withstood massive impacts as high as 82,000 ft-lb.

These tests prove that 9% nickel steel, without thermal treatment after fabrication, provides the high strength and toughness for safe, economical pressure vessels to contain and transport low-temperature liquids.

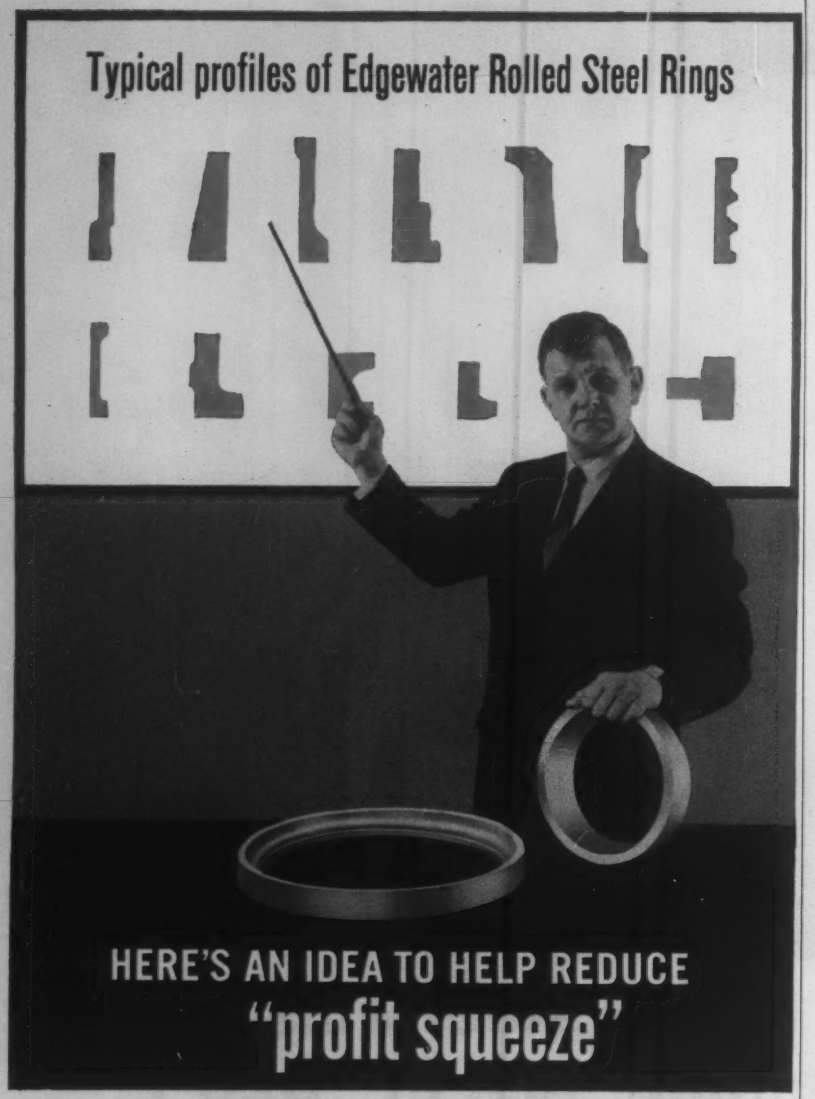
When you order, design, or build equipment for production, storage, or transport of liquefied gases at temperatures down to −320°F, specify 9% nickel steel for safety and economy. And for engineering data on 9% nickel steel, and other steels for low-temperature service, write to Inco.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

INCO CBI USS

INCO NICKEL

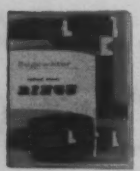
NICKEL MAKES STEEL PERFORM BETTER LONGER



Buy rings that are formed so close to finished shape and dimensions that very little machining will be needed. The result—less labor, less scrap loss, lower overall cost.

Edgewater rings are forged from solid blocks of steel, and rolled by a powerful ring-rolling mill to required cross-section shapes (see typical profiles above). Close tolerances minimize finishing operations.

Edgewater rolled steel rings are of uniform quality, strong and tough. Diameters: from 5 to 145 inches. Send drawings for recommendations and prices.



INTERESTING description of the ring-rolling process is given in this brochure, **Edgewater Rolled Steel Rings.** We will be glad to send you a copy.

EDGEWATER STEEL COMPANY
P. O. Box 478 Dept. MDE, Pittsburgh 30, Pa.

For more information, turn to Reader Service card, circle No. 342

bar stock instead of the more expensive hexagonal bar stock.

Extrusion vs machining costs

The pilot run showed that materials cost for an AMS 4902 titanium No. 10 nut produced by cold extrusion with screw machine finishing is 64¢, compared to $1.52 for a nut produced exclusively by screw machining.

In addition to significant cost savings on material and labor, the cold extrusion process also offers the advantages of 1) considerable strengthening through work hardening, 2) excellent surface finish, and 3) close dimensional control in the as-extruded condition.

Polypropylene Resins for Sheet Extrusion

Two new polypropylene resins for sheet extrusion are now available from Enjay Chemical Co., Div. of Humble Oil & Refining Co., 15 W. 51st St., New York 19. Both materials have a melt index of 0.6 and are adaptable to vacuum forming operations.

Escon 502 is a general purpose grade and sells for 42¢ per lb.

Escon 522 is designed for long-term service at elevated temperatures. It sells for 46¢ per lb.

KEY NO. 616

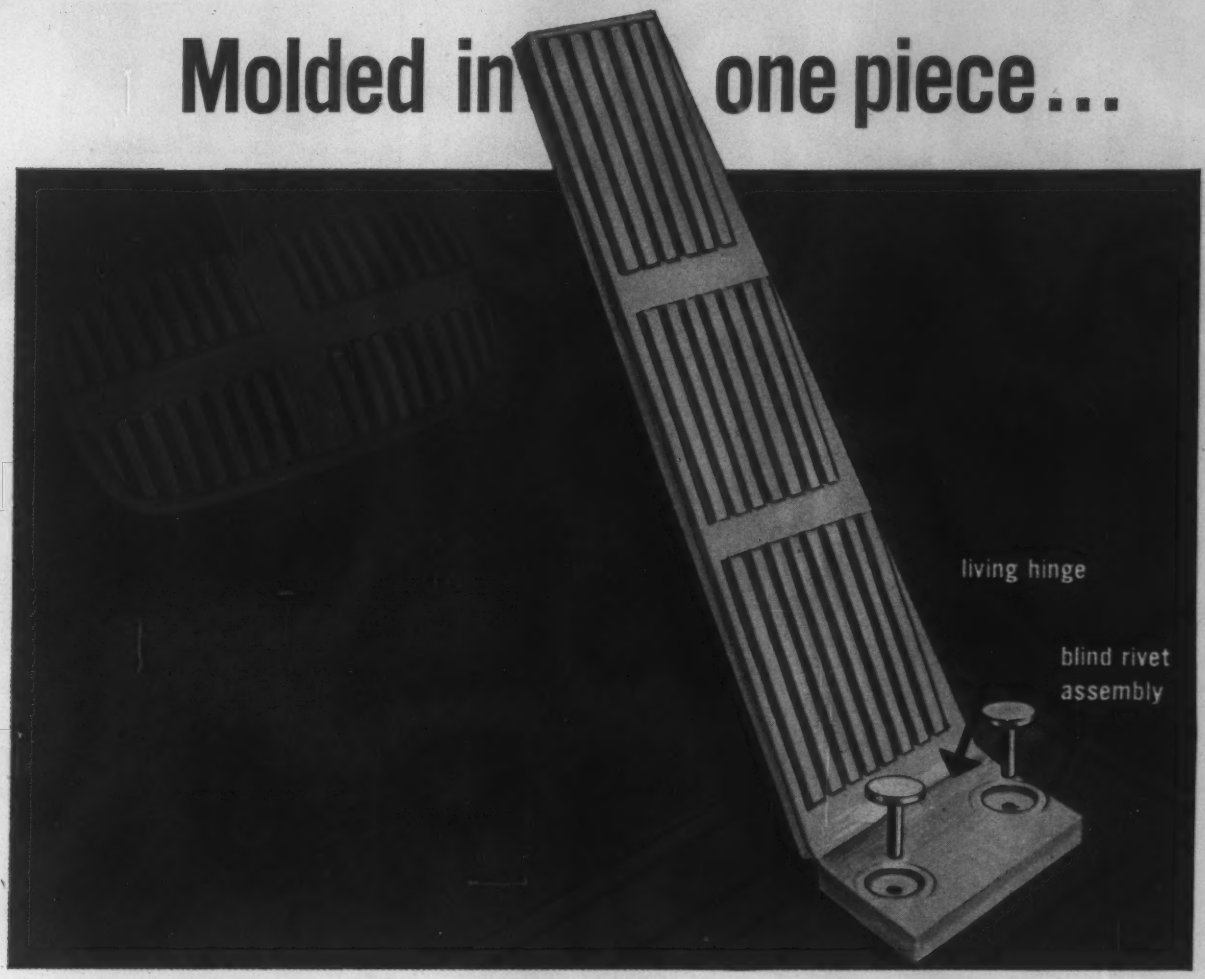
Silicone Additive for Rigid Urethane Foams

A new silicone additive is said to promote formation of uniform, fine-celled, rigid polyurethane foams (see accompanying photo). Called No. 113, the additive is available from Dow Corning Corp., Midland, Mich.

Dow says the additive has six advantages:

1. Shows little tendency to cause separation of fluorine-containing blowing agents.
2. Is less sensitive to variations in mixing than other silicone additives.
3. Permits the production of one-shot foams from crude isocyanates.
4. Does not cause gelation when

Molded in one piece...



the hinge lives on and on... because it's Escon® polypropylene

Escon polypropylene defies fatigue—a fact demonstrated by the integral hinge molded into this accelerator pedal, which easily passes the severe requirements of the automotive industry. The high strength and resilience of Escon polypropylene permit blind rivet assembly for fast, economical mounting to the floor panel.

Escon polypropylene parts are being investigated by auto makers to solve many difficult design problems. Glove compartments with "living hinges" molded in one piece, for example, promise to cut assembly costs and improve performance.

Besides exceptional dynamic fatigue resistance, Escon polypropylene gives you outstanding design versatility, high strength, low volume cost, easy processing, chemical resistance, negligible water pick-up, high heat distortion point and excellent electrical properties. For test samples or technical assistance, write to Enjay, 15 West 51st Street, New York 19, New York.

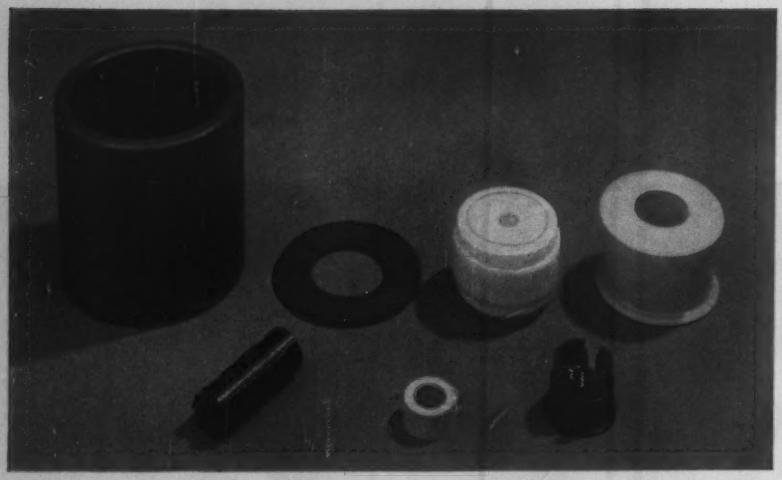
EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY PLASTICS

For more information, turn to Reader Service card, circle No. 341



METAL BEARINGS OR PLASTIC?

How do you decide?

Polymer is ready to help.

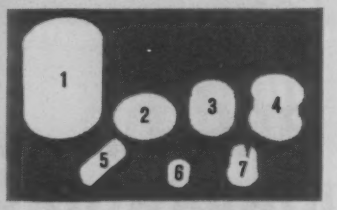
The above bearings are made of POLYPENCO industrial plastics. Their individual and unique bearing characteristics make them better than metal for many applications . . . with lower costs and improved performance.

In mechanical areas previously dominated by metals, engineers have found POLYPENCO bearing materials can perform better, wear longer (with or without lubrication) and materially reduce maintenance and replacement.

Another advantage—

Polymer's broad line of bearing plastics permits you to select the best combination of chemical, electrical, thermal and mechanical properties you need for a specific application.

Your Polymer representative stands ready to give you the technical assistance you require to select the best industrial plastic to improve performance of your parts and components—whether they are bearings, bushings, rollers, seals, gears, general tooling, wear strips or other wear parts. Write today for BR-O, general design catalog.



1. POLYPENCO® MC† NYLON A new economical nylon formulation to meet the need for large nylon bearings. It possesses high compressive strength and a heat distortion temperature above both type 6 and 66 nylon.

2. POLYPENCO K-51 PENTON* A chlorinated polyether with outstanding chemical resistance and high strength. Especially well suited for chemical applications that require better mechanical properties than TFE.

3. POLYPENCO TFE-FLUOROCARBON Possesses a very low coefficient of friction. Will not exhibit "slip-stick" and high starting torque is not required. Unique as a bearing material for lightly loaded applications.

4. POLYPENCO 101 NYLON A widely used plastic bearing material. Has good mechanical strength, chemical resistance and frictional properties. Easily machinable.

5. NYLASINT® NYLON PARTS Parts formed by cold pressing and sintering nylon powder. Are impregnated with oil and alloyed with fillers to provide premium wear resistance and outstanding dimensional stability.

6. FLUOROSINT® TFE COMPOSITION A TFE base material which has excellent mechanical stability up to 500°F. Exhibits superior wear resistance while maintaining the electrical and chemical resistance of unmodified TFE-fluorocarbon.

7. NYLATRON® GS NYLON A molybdenum disulphide-filled nylon formulated with premium bearing properties. The moly-sulphide filler provides a low coefficient of friction and excellent abrasion resistance.

*Hercules Powder Trademark
†The Polymer Corporation Trademark

POLYPENCO

THE POLYMER CORPORATION OF PENNA.
Reading, Pa.

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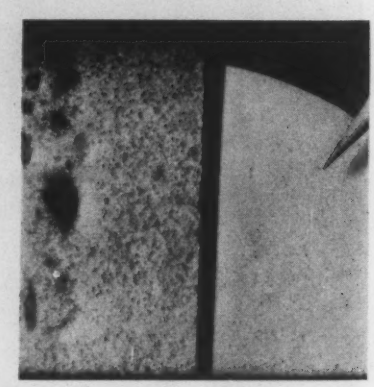
For more information, turn to Reader Service card, circle No. 421

What's new IN MATERIALS



***Uniform foam** at right is stabilized with Dow Corning's new additive and has more than 95% closed cells. The foam at left is stabilized with a conventional silicone additive and has less than 85% closed cells.*

added to isocyanate prepolymers or isocyanates.

5. Is not affected by most flame retardants, viscosity stabilizers, and color stabilizers commonly used with rigid foams.

6. Blends easily with other foam ingredients. **KEY NO. 617**

Beryllium Bolts Are Lightweight, Strong

What are claimed to be the strongest metal fasteners for their weight ever produced are now being made of beryllium by Standard Pressed Steel Co., Jenkintown, Pa.

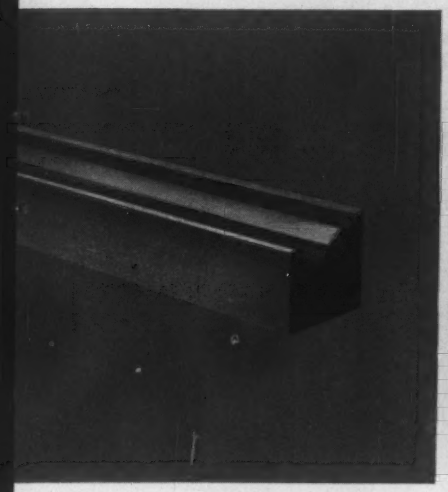
The beryllium bolts are said to have higher strength-weight properties than similar configurations in both standard steel and titanium bolts. Shear strength of the beryllium bolts is said to be 150% higher than that of titanium bolts and more than 200% higher than that of standard steel bolts on a strength-weight basis. In fatigue, the beryllium bolts are nine times better than standard steel bolts and about two times better than titanium bolts on a strength-weight comparison of endurance limits.

continued on p 152

PROPERTIES OF BERYLLIUM BOLT

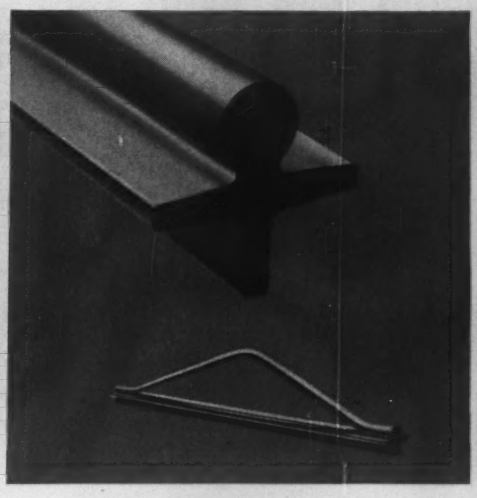
Tensile Strength, psi	75,000
Shear Strength, psi	65,000
Fatigue Strength, psi	45,000

How to cut costs to make a better product



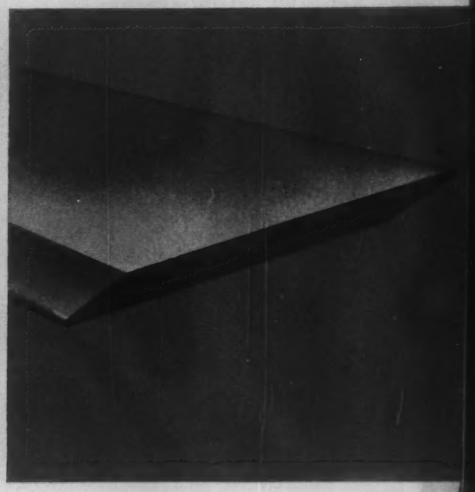
Costly machining eliminated

Manufacturer used to machine square stock to produce typewriter carriage rails. By changing to this special steel section, accurately hot-rolled and then cold-drawn to precise dimensions, he eliminated much costly machining, avoided scrap loss. Production rate was increased considerably.



For greater strength and durability

This custom-rolled section makes possible the economical fabrication of a railroad brake beam. Our customer first separates most of the "round" section from the "tee" by splitting the web between them to points near each end of the bar. He then compresses the "tee" portion of the bar, reducing its length and forcing the "round" outward to form a unitized truss. He reports this one-piece beam gives more reliable service, and is stronger than beams made by welding, bolting, or casting.



Faster production . . . using less steel

Our customer produced grader blades by flamecutting square-edge plate. By substituting this double-bevel special section, he eliminated the cutting operation, improving both his production rate and the appearance of his product. Because less steel is needed, the section costs less per foot, and shipping costs are reduced.

DESIGN WITH SPECIAL BAR SECTIONS, HOT-ROLLED TO YOUR SPECIFICATIONS

When you use special sections you buy less steel. You generate less scrap. Shipping and handling costs go down. Special sections reduce machining and fabricating operations and cut production costs. Special sections provide more freedom of design, and a stronger, more durable product—a product that has more sales appeal.

Could you use special bar sections, hot-rolled to your own product specifications? We'd be happy to discuss the possibilities with you . . . just call or write the Bethlehem sales office nearest you.

Steel *for Strength . . . Economy . . . Versatility*

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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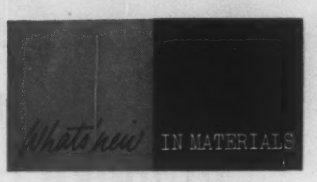


The producer says that a chemical surface finish on the bolts improves ductility and shear strength. And a large and rounded root in the thread, 1.5 to 2.5 times that of conventional rounded roots, greatly increases thread life of the beryllium bolts.

The company supplies the bolts in standard shear bolt configurations in No. 6 through ⅜-in. dia sizes.

KEY NO. 618

Electrolytic Cutting

New metalworking machines that make use of a recently developed electrolytic technique will be manufactured and marketed by Ex-Cell-O Corp., 1202 Oakman Blvd., Detroit, under a licensing agreement with Steel Improvement & Forge Co., developer of the process. Steel Improvement will market electrolytic solutions.

The new technique, described in the Feb '61 issue of this magazine (p 145), can be used for milling, drilling, sawing and contour turning of hard, high strength metals. The developer says that there is no metal-to-metal contact between workpiece and the tool, and no tool pressure as with conventional machining processes.

KEY NO. 619

Glass-Plastics Tubes Are Centrifugally Cast

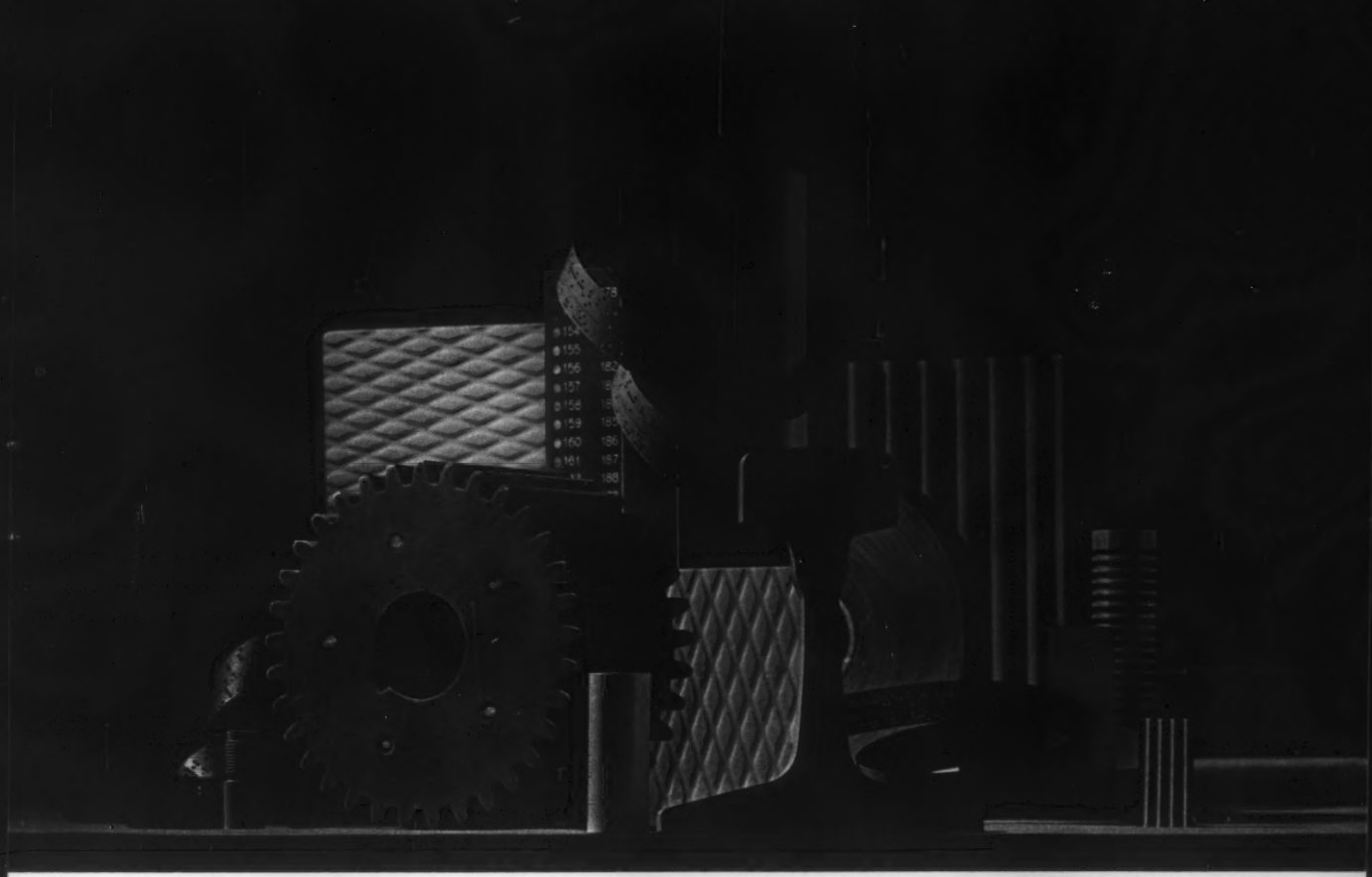
Fiberglass-reinforced plastics tubing is being turned out by a new centrifugal casting process, details of which have not been revealed. The method is said to produce uniformly dense tubing suitable for use as paper and foil winding cores, chemical process pipelines and other applications.

The tubes are available from Ordnance Div., Clevite Co., 540 E. 105th St., Cleveland 8, Ohio. They are supplied in lengths up to 93 in. in any wall thickness. Outside diameters are 10, 12¾ and 15 in.

Inserts molded in tubes

The producer says ceramic, plastics or metal inserts and closures can be integrally molded anywhere

For more information, circle No. 423 ➤



THIS remarkable plastic may trigger a new (or cost-saving) design idea for you

National Vulcanized Fibre is unique. It's a tough, cellulosic plastic—not mere paper or fiberboard. Vulcanized Fibre possesses an unusual combination of mechanical, electrical and thermal properties. For example . . .

It weighs one-half as much as aluminum, yet is one of the strongest materials known per unit of weight. It's tough, durable and cushions the shock of repeated blows.

Vulcanized Fibre has superior arc-resistance. It comes in standard and special grades, including a fire-resistant grade called "Pyronil." It can be machined, formed or deep-drawn into intricate shapes, and can be combined with other materials . . . aluminum, rubber, "Mylar," copper, laminated plastic, plywood, to name a few.

You can polish it, paint it, lacquer it, emboss it. And regardless of the finish, it resists oils, gasoline, fungi, most solvents. Most surprising is its low cost.

Find out for yourself why National Vulcanized Fibre is "the plastic with a million uses." There's a free sample kit waiting for you at a nearby NVF sales office. Check Sweet's Product Design File 2b/Na for the one nearest you. Or write directly to Dept. PP, Wilmington, Delaware.

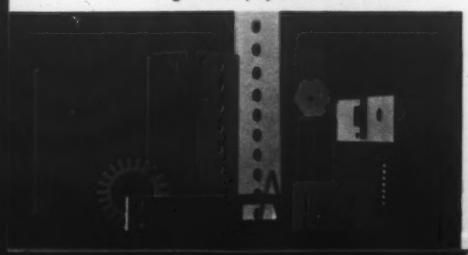
116 Choices: One Source This is the latest count of the different plastics and grades NVF can offer in your search for the *one best material.* Add to this total *the* one special grade that can be developed from scratch to meet your particular need. This full range of materials is backed by complete engineering services . . . from application assistance up to and including the delivery of 100% usable, precision-fabricated parts . . . in any quantity, on time!

Call the NVF Sales Office near you. It's a direct line to single-source help on your current materials problem.

NVF

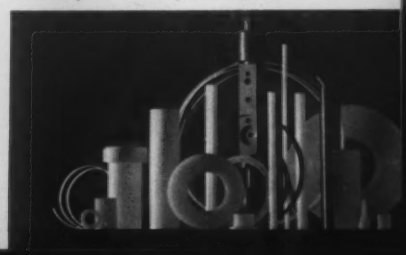
NATIONAL VULCANIZED FIBRE COMPANY
WILMINGTON 99, DELAWARE
In Canada: NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

5 grades of polyester



85 Phenolite® laminates

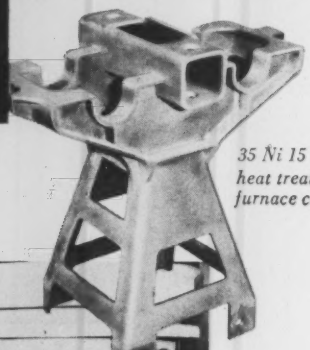
3 thermoplastics . . . nylon, Delrin®, Penton®



DURALOY

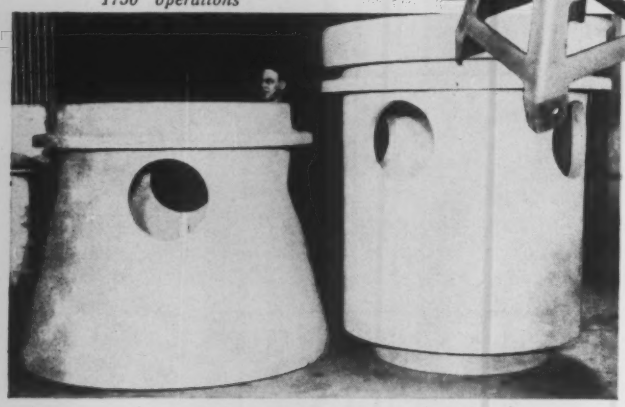
High Alloy CASTINGS for METAL TREATING

35 Ni 15 Cr carburizing furnace casting



35 Ni 15 Cr heat treating furnace casting

Heat treating stools for 1750° operations



● ***Sound castings to withstand the high operating temperatures and wide temperature ranges without deformation.***

Nickel-chrome castings have long been the 'standard' for heat treating and annealing operations—and for close to forty years Duraloy castings have been considered by many metal working plants to be the 'standard' for meeting the industry's sound casting requirements.

The three Duraloy castings illustrated typify the kind of work we do for the metal treating plants.

We're in a position to cast any shape or size and of any alloy to meet your requirements. Send for Bulletin G-159.

ALLOY CASTING INSTITUTE ACI MEMBER

The DURALOY Company

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Chicago Office: 332 South Michigan Avenue, Chicago, Illinois
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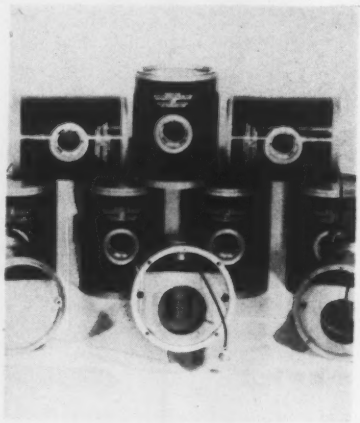
For more information, turn to Reader Service card, circle No. 384

What's new IN MATERIALS



Warhead sections *from an underwater device are made of centrifugally cast reinforced plastics tubing.*

inside the tube during casting, or they can be added after casting. Bonds of these inserts and closures to the tubing are said to be strong and permanent: shear strength of bonds with aluminum is 2500 psi.

The centrifugally cast tubing is said to be unaffected by prolonged exposure to oil, grease, water, solvents and most chemicals, except concentrated acids and alkalis. The reinforced tubes can be used at temperatures over 300 F.

KEY NO. 620

High Strength Steel for Pressure Vessels

A new high strength steel for pressure vessel applications has been introduced by Great Lakes Steel Div. of National Steel Corp., Detroit 20. The steel, called N-A-XTRA 100 has a minimum tensile strength of 115-135,000 psi and a minimum yield strength of 100,000 psi.

A big advantage of the steel is that it has ASME (American Society of Mechanical Engineers) approval for pressure vessel use (Case No. 1297). Another advantage is that it sells for $47 a ton less than T-1 steel, "the only other super strength rated and approved pressure vessel steel."

According to the producer, the steel keeps its strength at both low

For a prepaint treatment to make your product look its best longer . . .

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 FIELD SERVICE MEN • OVER 160 MATERIALS

Structo Mfg. Co. now offers products

protected with CrysCoat® under the paint

It's no picnic for an outdoor grill during the barbecue season. Continually exposed to weather and water, its finish takes a heavy beating. Yet it can be made to look its best longer, when there's CrysCoat protection under the paint.

That's why Structo Manufacturing Company standardizes on Oakite CrysCoat not only for steel grills, but also for its renowned line of toy trucks, tractors and other popular items. CrysCoat first, and *then* paint, locks the finish on, stops creeping rust in its tracks, prevents it from under-cutting paint and ruining the appearance of a product. Quality products *deserve* this quality prepaint treatment . . . and it costs so little.

There's an Oakite CrysCoat process for every manufacturing requirement and every production setup.

- Iron phosphate coating in tanks
- Iron phosphate coating in spray washers
- Zinc phosphate coating in tanks
- Zinc phosphate coating in spray washers
- Heavier coatings or lighter coatings
- High or low temperature processing

All bond paint to metal; all increase corrosion resistance to prevent paint peeling; all improve product appearance. Send for Cryscoat Bulletins. Write Oakite Products, Inc., 32H Rector St. N. Y. 6, N. Y.

OAKITE

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years' leadership in industrial cleaning

For more information, turn to Reader Service card, circle No. 394

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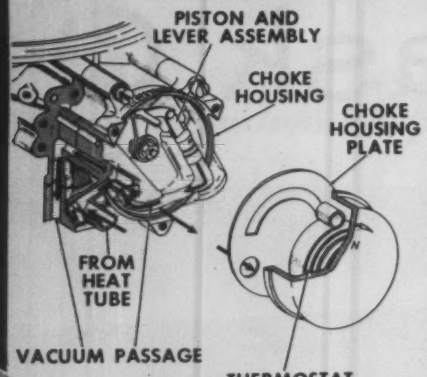
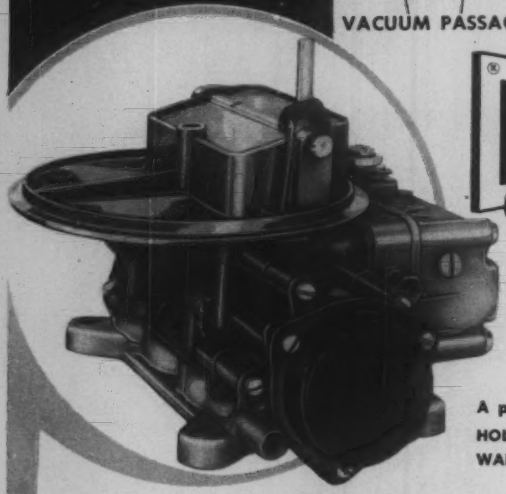
THERMOSTATIC BIMETAL
ACTUATES ANOTHER PRECISION PRODUCT...





HOLLEY Carburetor Co.

AUTOMATIC CHOKE

A product of
HOLLEY CARBURETOR CO.
WARREN, MICHIGAN

Cold-weather starts — or non-starts — were once the bane of every motorist's existence. The attendant stalling and loss of power due to cold-impaired carburation are now a thing of the past, thanks to the efficient Holley Automatic Choke. A properly running engine, equipped with the famous Holley Carburetor and Automatic Choke, will start quickly, positively in the coldest weather. Here's how:

The thermostat is a bimetal coil which — when cold — closes the carburetor choke plate to allow a "rich" concentration of fuel to enter the combustion chamber. In starting, manifold vacuum is applied to the piston and lever assembly, which attempts to open the choke plate. The cold bimetal resists this motion, at the same time allowing the choke plate to open slightly; admitting only enough air to keep the engine running. As engine heat is generated, it causes the thermostat coil to relax and open the choke plate further and further till operating temperature is attained, at which time the choke plate is fully open.

The actuating element — "thermostat" — is a coil of precision Chace Thermostatic Bimetal produced to Holley's exact specifications. The result is a device which will perform this important function *every time* the car's engine is started. That's dependability; the dependability Chace has developed in more than a third of a century of specializing in the manufacture of one product: precision Thermostatic Bimetal produced to specifications. Chace Thermostatic Bimetal is known the world over by companies large and small, who know that when they specify Chace, they also specify dependability.

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It contains many well illustrated pages of valuable design data and examples of successful applications of bimetal! More than 40 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

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Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

IT BENDS WITH THE HEAT

For more information, turn to Reader Service card, circle No. 430

What's new IN MATERIALS

COMPOSITION OF PRESSURE VESSEL STEEL (%)

Carbon	0.15-0.20
Manganese	0.80-1.10
Phosphorus	0.035 max
Sulfur	0.040 max
Silicon	0.50-0.80
Chromium	0.50-0.80
Molybdenum	0.18-0.28
Zirconium	0.05-0.15

and high temperatures, and has excellent weldability under constrained conditions.

The steel is said to permit the design of pressure vessel storage tanks that are 32% lighter weight than tanks made of conventional high strength steels.

Noted briefly in our May issue.

KEY NO. 621

Self-Luminous Paint Safe to Use on Dials

A new self-luminous paint containing tritium, a radioactive form of hydrogen, has been approved by the Atomic Energy Commission for use on watch dials and timepieces.

Called Lumichron, the paint is available from New England Nuclear Corp., 575 Albany St., Boston 18. It sells for 35¢ to $10 per gm depending on brightness range.

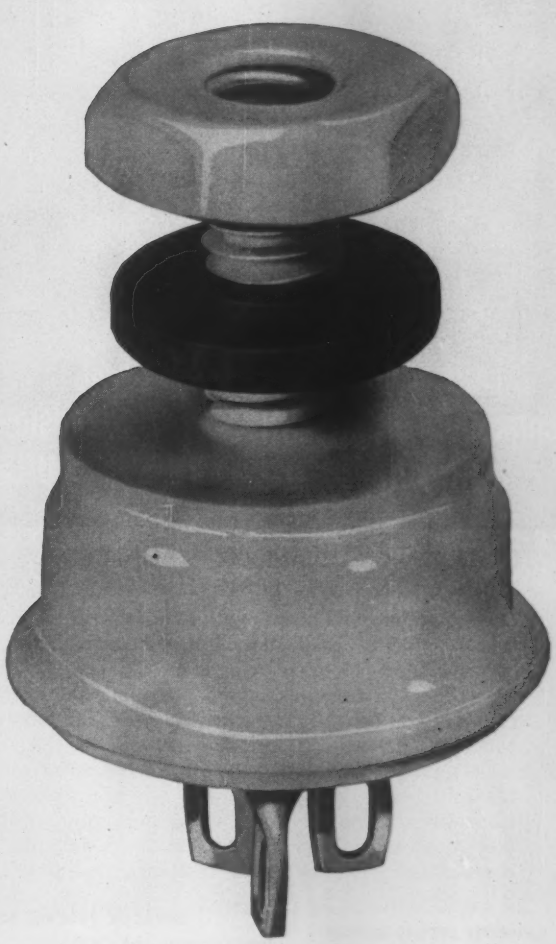
New England Nuclear says tritium, described in the Sept '58 issue of this magazine (p 91), is probably the least dangerous of all the radioactive isotopes. The radioactivity it emits is so weak that it cannot penetrate an ordinary sheet of paper.

KEY NO. 622

Thermal Insulation for Cryogenic Applications

A synthetic calcium silicate insulation for cryogenic applications has an apparent mean thermal conductivity value of 0.100 Btu/hr/ sq ft/ °F/in. as determined between liquid nitrogen and ambient temperatures at 1 atm. This value is said to be significantly lower than that for presently used low temperature insulating materials.

Called Micro-Cel, the insulation is available from Johns-Manville Corp.,



Familiar product . . . new use

In the hands of experts, a well-known product has found a new use, brought about by today's fast moving technology. A spacer with electrical insulating and special mechanical properties was required for this stud-mounted power transistor. CDF solved the problem with paper phenolic rolled tubing, a long-established grade. Fabrication of the spacer is accurate and low cost on automatic screw machines.

Result: Reliability is assured through use of a time-tested and proven material, while costs are kept to the minimum.

A few facts on the tubing: (1" x 1⅛")

Dielectric strength, perp., vpm	400
Min. density	1.12
Water absorption, %	3.0
Axial compression, psi	13,000

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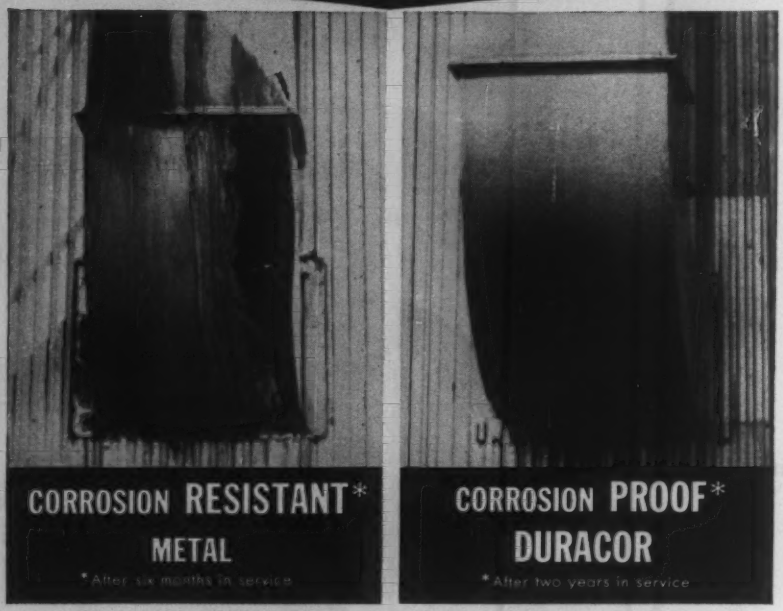

LIGHT, STRONG DURACOR REPELS CORROSION BETTER THAN METAL . . . LASTS LONGER . . . COSTS LESS

Duracor reinforced plastic withstands attack from almost every known solvent, alkali, reducing agent or oxidizing acid. It can be sawed, drilled, filed or sanded . . . readily fabricated into pipe, duct, tanks, hoods, and other special equipment. High resistance to heat, flame, chemicals and abrasion makes Duracor ideal for severe corrosive service in the metalworking, textile, paper, food and chemical processing industries. Duracor has a high strength/weight ratio . . . needs no exterior protection. Installation is quick, easy and economical. Duracor is fabricated exclusively by The Ceilcote Company, producers of corrosion-proofing materials for industry for more than 30 years.

CEILCOTE OFFERS DESIGN ASSISTANCE . . . BUILDS AND INSTALLS DURACOR VENTILATING SYSTEMS AND PROCESS EQUIPMENT TO CUSTOMER SPECIFICATIONS

DURACOR PROCESS EQUIPMENT

Tensile Strength p.s.i. (D638-S2T)*	11,000-15,000
Flexural Strength p.s.i. (D790-49T)*	20,000-30,000
Tensile Modulus of Elasticity p.s.i.	1.2-1.4x10⁶
Flexural Modulus of Elasticity p.s.i.	0.78-1.6-10⁶
Coefficient of Linear Expansion	9.5x10⁻⁶ in./in./°F.
†Maximum Temperature (Exposure)	500°F.

DURACOR VENTILATING EQUIPMENT

Tensile Strength p.s.i. (D638-S2T)*	8,000-12,000
Flexural Strength p.s.i. (D790-49T)*	14,000-22,000
Flexural Modulus of Elasticity p.s.i.	0.70-1.4x10⁶
Coefficient of Linear Expansion	10.5x10⁻⁶ in./in./°F.

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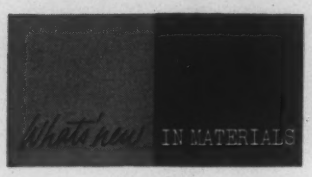

Celite Div., 22 E. 40th St., New York 16.

The insulating material is a free-flowing powder that is said to be free of explosion and fire hazards. It is compatible with commonly used liquid gases such as oxygen and hydrogen. Its loose weight density is 4.5 to 6 lb per cu ft; packed density is 6 to 9 lb per cu ft.

The insulation is suitable for both stationary cryogenic applications such as cold boxes, and transport applications such as trucks and trailers. **KEY NO. 623**

Vinyl-Lined Steel Pipe

A new and economical method for applying a seamless, corrosion resistant vinyl lining to the inside of steel pipe has been developed by Lithcote Corp., 5000 W. Lake St., Melrose Park, Ill.

A big advantage of the method is the low cost of the lining. Lithcote's prices, exclusive of pipe, are approximately $1.60 per sq ft for 1/16-in. thick lining and $1.90 for ⅛-in. lining. The plastic-lined pipe is supplied in sizes ranging from 3 to 36 in. in dia and in lengths up to 60 ft.

In the coating process, a special roller-coater applies a vinyl plastisol coating to the inside of pipe; after coating, the vinyl is fused to the pipe by heating in an oven.

(For information on another low cost method for coating the inside of pipe, see M/DE, Apr '61, p 10.) **KEY NO. 624**

Welding Torch Can Be Adjusted to Any Angle

Better and less costly welds in hard-to-reach corners are said to be possible with a new tungsten inert-gas arc welding torch.

Reason: the torch can be readily adjusted to any angle, and it can be extended to reach into difficult recesses. Previous methods required maintaining a stock of torches with various heads and angles that were changed as needed for the job at hand.

The welding torch is available from Falstrom Co., 147 Falstrom

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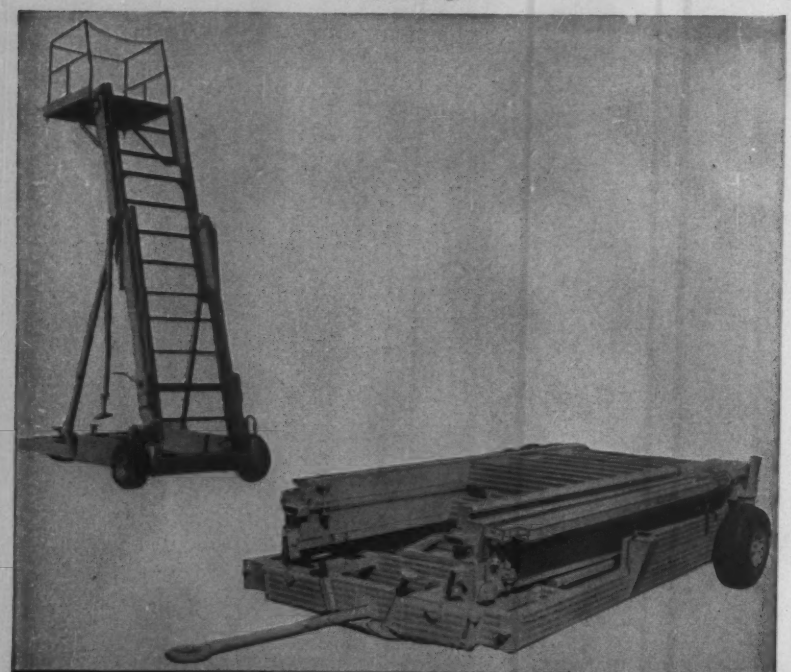
LUBRICATION REPORT

(TFE coating)



Application: *Portable Aircraft Maintenance Stand Lubrication.*

Problem: *To Minimize sliding friction at widely varying temperatures.*

Solution: *'EMRALON® 310 (a tetrafluoroethylene pigmented, bonded film lubricant) — spray-applied and baked at 300 F. for one hour.*

RESULT: *ALL-WEATHER COATING GIVES TELESCOPING STAND NEEDED LOW-FRICTION SLIDING SURFACES*

This lightweight portable aircraft maintenance stand was developed for use by the U. S. military forces by South River Metal Products Co., Inc., of South River, N. J. Approximately 40 lineal feet of telescoping surfaces are contained in the stand which elevates to 13 feet for use, and compacts to a height of only 2 feet for transporting. Tests showed that the sliding magnesium sections were readily subject to galling and seizure. The dry-film coating obtained with Acheson's 'EMRALON' 310 provides the necessary lubrication through an ambient range from desert heat to Arctic sub-zero temperatures . . . and does not cake, evaporate or freeze.

Perhaps one of Acheson's series of TFE coatings can help solve your dry-film lubricating problem. Write for 'EMRALON' 310 or 'EMRALON' 320 (air dry) Product Data Sheets. Dept. ME 71

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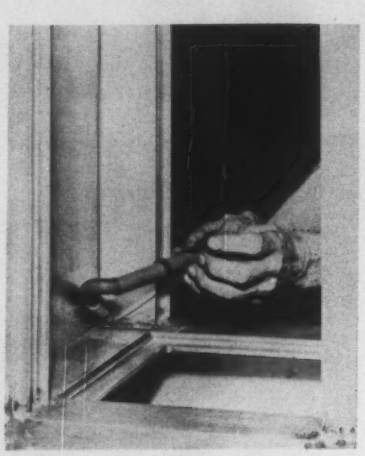
What's new IN MATERIALS



***Recessed corner** like the one shown here can be readily welded with new controlled angle torch.*

Ct., Passaic, N. J. It is a water cooled model rated at 180 amp a.c.-d.c. for continuous duty and 300 amp a.c.-d.c. for intermittent duty.

KEY NO. 625

Epoxy Compounds for Electrical Applications

Two new epoxy compounds have been introduced recently for electrical applications. One compound is designed for encapsulating and the other for potting.

1. Encapsulating compound

The encapsulating compound can be molded by transfer or compression molding techniques to produce accurate, low cost encapsulations on coils, small transformers, resistors, capacitors and other parts where large volume production prohibits economical use of liquid casting techniques.

The compound, called Randac No. S-7010, is available from Mitchell-Rand Mfg. Corp., 51 Murray St., New York 7. It is said to have good resistance to thermal shock, low water absorption, good electrical properties, and excellent Class F (300 F) temperature stability.

KEY NO. 626

2. Potting compound

The potting compound is said to cure with negligible shrinkage and

For more information, circle No. 429 ➤

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better because—

better because HOEGANAES stainless steel powders improve AIREX spinning reel parts production

The parts are brake drums and guides, produced by THE LIONEL CORPORATION, using HSIC 316L stainless steel powder. Assembly problems and extra production operations were eliminated.

In addition, Hoeganaes stainless powders provided better corrosion and wear resistance qualities. Cost savings of 30% and 26% when compared to former machining methods.

Get more facts about HSIC high alloy powders—write for free literature; ask for Bulletin #128.

HSIC

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CLEVELITE* TUBING
can save you money!

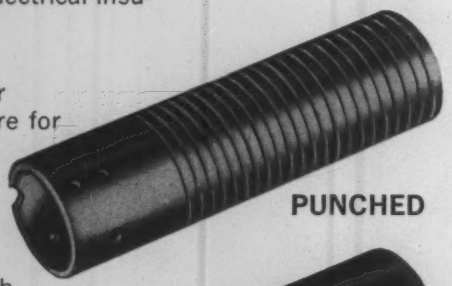
This versatile laminated phenolic tubing is often only *half the cost* of many other materials!

Clevelite *combines* desirable physical and electrical characteristics which suggest a broad range of applications where tubular construction and low unit cost are important factors.

Clevelite is very light, structurally strong and easily machined. Highly resistant to moisture, unaffected by solvents and oils, it has excellent electrical insulation properties.

SAWED

Some of the more popular uses of Clevelite tubing are for radio and television equipment, electric motors, relays, controls, transformers, and many other electrical products. Other applications, in which dimensional stability and good wearing qualities are required include paint rollers, bobbins, housings, pre-forms, cores, spacers and sleeves.



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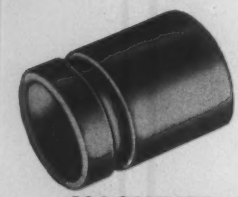
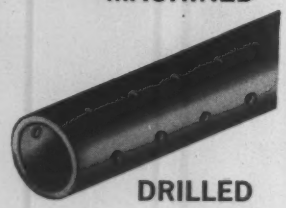


MACHINED

Clevelite is produced in seven grades, round or rectangular, with thin or heavy walls, plain or fabricated.



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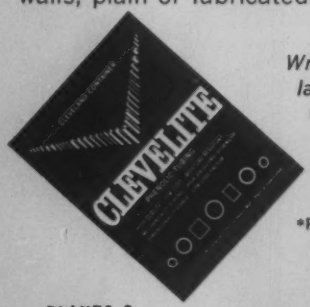

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For more information, turn to Reader Service card, circle No. 348

internal stress. It is called No. 1201 and is available from Wright Plastics Inc., 114-13 Atlantic Ave., Richmond Hill, N. Y.

The resin is recommended for potting electronic assemblies, motors, transformers and other parts that might be sensitive to stresses encountered during cure. The molded resin has good thermal shock resistance over the temperature range —150 to 350 F. **KEY NO. 627**

New Aluminum Alloy for Automotive Trim

A new aluminum alloy for exterior automotive trim applications has been developed by Kaiser Aluminum & Chemical Corp., 300 Lakeside Dr., Oakland 12, Calif.

According to Kaiser, the alloy has substantially improved tensile (35-45,000 psi) and yield (30-40,000 psi) strengths compared with other aluminum alloys used for automotive trim.

The anodized appearance of the alloy is about the same as that of other aluminum alloys used by the auto industry for bright trim parts.

Called 5252, the alloy is sold in coil sheet form in thicknesses ranging from 0.019 through 0.047 in. Maximum width is 48 in.

KEY NO. 628

FEP Fluorocarbon Sold as Dispersion

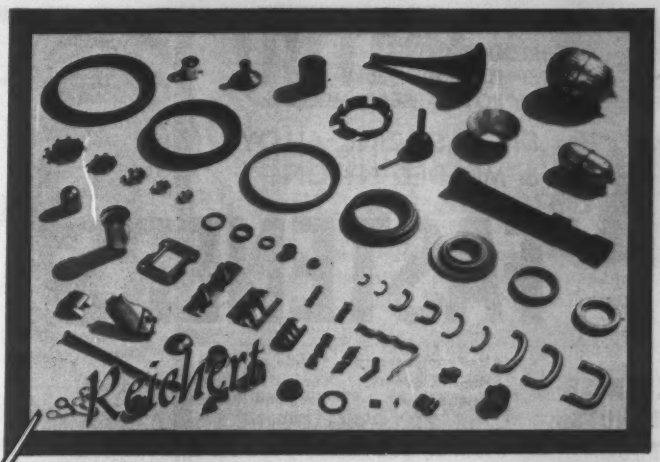
Teflon FEP fluorocarbon resin introduced in late 1956 (see *Materials & Methods*, Nov '56, p 161), is now available as a water-base dispersion and as two formulated spray finishes.

The fine dispersion, called Teflon TE-9500 FEP, contains 6½ lb of solids per gal. It is marketed by Du Pont's Polychemicals Dept., Wilmington 98, Del. at an introductory price of $12 per lb in 30-gal drums.

The dispersion is expected to be used as a 360 F (formerly Class H) impregnant and surface coating for wire and cable. Films of the dispersion are said to have low permeability and excellent heat sealability.

The two formulated FEP spray

Deep Drawn,
Light and Medium
COPPER
BRASS
ALUMINUM
MONEL
STAINLESS
HIGH CARBON
ALLOY STEELS



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DIE CAST ZINC ALLOY
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Integral wide-diameter washer base eliminates need for separate washer. Cuts your cost, saves assembly time and labor. Specially suitable for use with bolt holes, adjusting slots, soft surfaces. Holds better because of greater seating area. 14 thread sizes—#6 thru ⅜". GRC —world's most complete stock of standard and special wing nuts.

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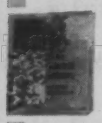
Produced in one high speed automatic operation, GRC's exclusive methods assure uniformity, smooth, rustproof & corrosion resistant surfaces and the lowest possible cost. New kinds of fasteners never before available . . . modifications in stock fasteners for specified use . . . infinite variety in styles, types and sizes, have been made possible by GRC's special automatic die casting and molding machines.



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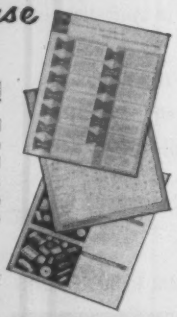

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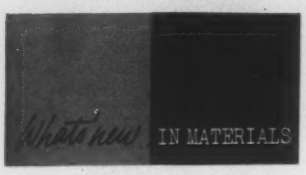


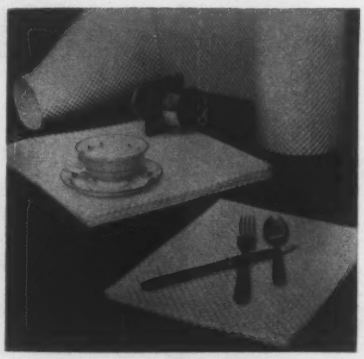
finishes are available on a trial marketing basis from Du Pont's Fabrics and Finishes Dept., Wilmington 98, Del. The finishes are called No. 851-454 enamel green and No. 852-401 clear. Both finishes fuse to metal and other surfaces at temperatures ranging from 575 to 625 F.

KEY NO. 629

Metal Fibers Used in Resistance Welding

An improved resistance welding technique uses a piece of fiber metal sheet between surfaces that are to be welded. The fiber metal sheet greatly increases the ratio of contact resistance to bulk resistance, permitting the metal in the fiber mat to reach its melting point quickly while the base metal remains cool.

The improved welding method was developed by Armour Research



Packaging for polished products —A new polystyrene foam packaging material is said to be non-abrasive, non-linting, non-dusting and chemically inert. It is recommended especially for packaging such highly polished products as china, photographic lenses and stainless steel dinnerware. Called Flex-Pak, the material is available from Dyna-Foam Corp., Ellenville, N. Y. The packaging material is the first in a series of products developed from an extruded polystyrene foam plastic introduced by Dyna-Foam last fall (M/DE, Oct '60, p 220).

KEY NO. 630

Electrically conductive epoxy cement...

ends soldering!

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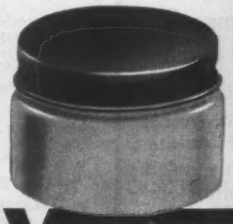

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6-27

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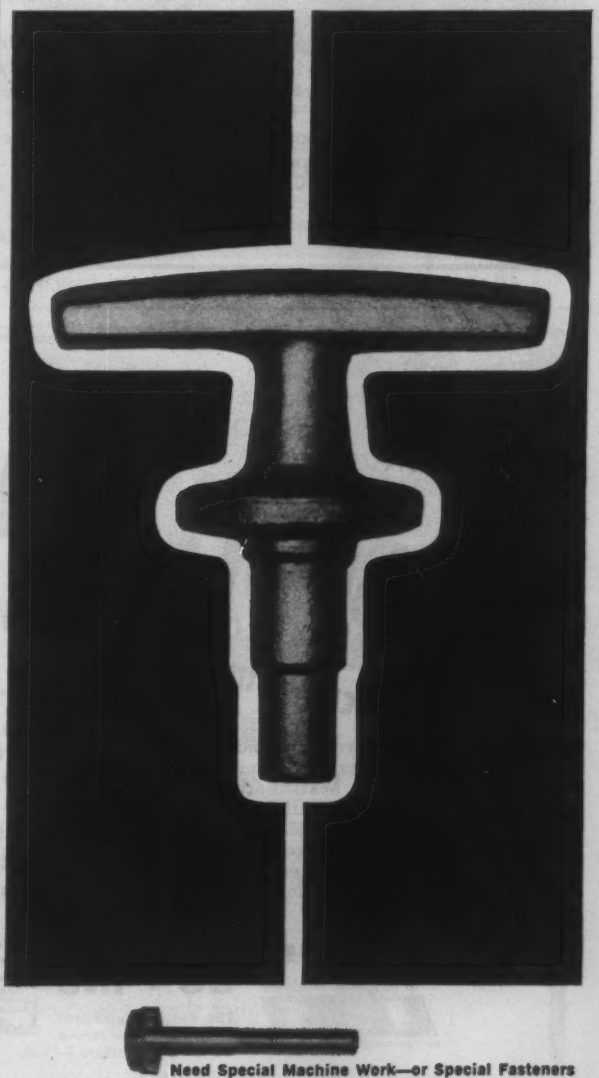

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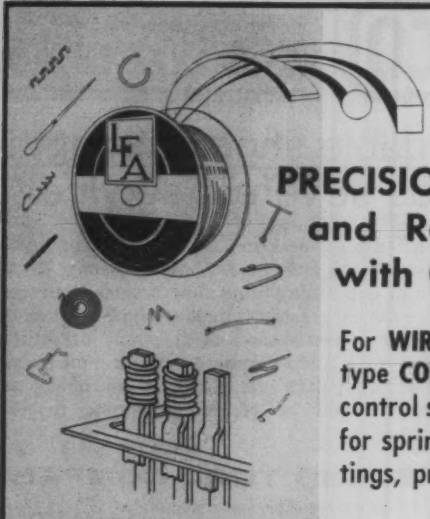

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What's new IN MATERIALS

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2. Opens the possibility of making resistance welds on high conductivity metals like copper.
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4. Gives better dimensional control and greater reproducibility in projection welding.
5. Gives less electrode indentation in spot and seam welding.

Other News

Metals

▸ Laminated shims of titanium can now be made to customer specifications by Laminated Shim Co., 1600 Union St., Glenbrook, Conn. The titanium shims are 0.003 in. thick.

KEY NO. 631

▸ Small diameter tubing made of 1% zirconium-columbium alloy is designed for use as fuel element cladding and heat exchanger tubing in nuclear reactors. The tubing is supplied in sizes from 0.012 to 1.125 in. o.d., and in lengths up to 24 ft by Superior Tube Co., 1548 Germantown Ave., Norristown, Pa.

KEY NO. 632

▸ An improved iron-chromium-aluminum electrical resistance wire with high resistivity and low temperature coefficient of resistance characteristics is available from Molecu-Wire Corp., Eatontown-Freehold Pk., Scobeyville, N. J. The wire, called Mesoloy, is supplied coated or uncoated in diameters ranging from 0.0005 to 0.010 in.

KEY NO. 633

Plastics

▸ A new polyethylene resin for blown tubing and cast film is said to have excellent clarity and high strength. Designated Petrothene 232, the resin is suitable for a variety of packaging applications. It is marketed by U. S. Industrial Chemicals Co., Div. of National Distillers and Chemical Corp., 99 Park Ave., New York 16.

KEY NO. 634

▸ A new dry film lubricant provides a slick surface on metal and non-

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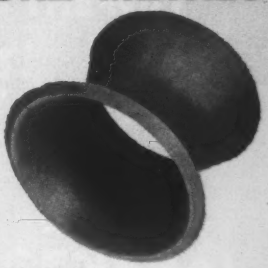
Molybdenum
Tantalum
and
Others



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What's new IN MATERIALS

metallic parts over the temperature range −120 to 500 F. The lubricant, which contains a fluorocarbon dispersion, is packaged in an aerosol container. It is marketed by Fluoro-Plastics, Inc., 3604-D Filbert St., Philadelphia 46.

KEY NO. 635

▸ A new vinyl chloride–vinyl acetate resin is expected to find use in phonograph records, flooring, rigid and flexible calendered sheets, and molded products. The resin, designated Pliovic S-51, is available from Goodyear Tire & Rubber Co., Chemical Div., Akron 16, Ohio. It is a low molecular weight resin produced as a fine, white powder.

KEY NO. 636

Other nonmetallics

▸ Glass parts that have been metallized for soldering are available in a variety of shapes and sizes from Electro-Seal Corp., 946-A North Ave., Des Plaines, Ill. The metallized glass parts are expected to be used in hermetically sealed units where it is desirable to view the operation of sealed parts.

KEY NO. 637

▸ A fused mullite refractory ($3Al_2O_3 \cdot 2SiO_2$) is currently available in a wide range of shapes from Norton Co., Refractories Div., Worcester 6, Mass. The material has high purity, excellent thermal shock resistance, good hot strength and excellent load-bearing capacity. Potential uses: batts, saggers and kiln furniture.

KEY NO. 638

Finishes

▸ A new acrylic film-forming resin dries at room temperature to form a clear, tough, glossy, water-insoluble film. Called Carboset 511, the material is available from B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio. Thin films of Carboset 511 can be used to protect highly polished metal during shipment; when the sheets are ready for use, the film can be removed with a mild alkali.

KEY NO. 639

▸ A new flame resistant coating for coloring aluminum foil has been introduced by Rubba, Inc., 1015 E. 173rd St., New York 60. The coating, called Rubbafoil, air dries in 30 to 90 sec.

KEY NO. 640

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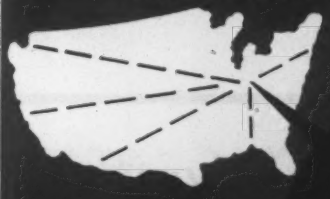

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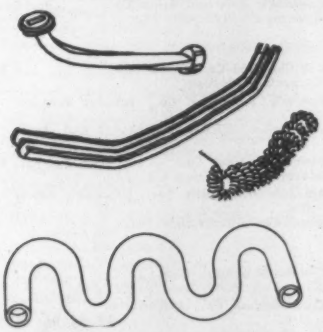

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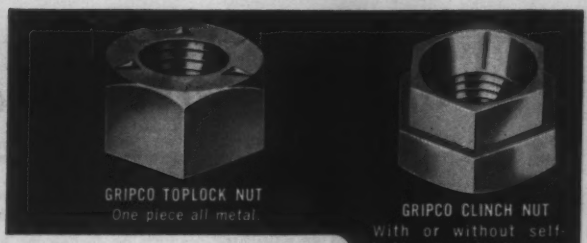

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Adhesives 74, 129, 135
Aluminum and its alloys..... 32
Bearing materials 150
Brazing alloys 88
Carbon, graphite 28-29, 45, 60, 140, 142
Casting alloys 2
Castings 140-141, 154
  Centrifugal 55
  Continuous 49
  Die 2, 23, 84
  Investment 35, 144
  Sand 144
  Shell mold 144
Ceramic fibers 58-59
Ceramics 57, 164
Ceramoplastics 24
Cleaners, metal 155
Cleaning, ultrasonic 25
Coatings
  Chemical conversion 48, 50-51, 155
  Organic 14, 85, 160
  Plastisol 66
  Strippable 70
Contact materials, electrical 30-31
Copper and its alloys inside front cover, 165
Expanded metals 134-135
Extrusions
  Metallic 169
  Nonmetallic 64
Fabrics
  Coated 83
  Industrial 75
Fasteners, mechanical.....164, 167, 169
Felts .....163, inside back cover
Forgings 46, 56, 81, 140-141, 148, 165
Heating equipment 162
High temperature metals 167
Impact extrusions 140-141
Insulation 24
Laminates, plastics 76, 153, 157, 162
Lead and its alloys 90
Low melting alloys 169
Lubricating materials 160
Metal powder parts 3, 140-141
Metal powders 161
Mica, glass-bonded 24
Nickel and its alloys 4, 147
Nitrides 168
Plastics
  ABS 62-63, 137
Cellulose acetate 145
Cellulose propionate 145
Diallyl phthalate 85
Fluorocarbons 150, 168
Foam 125
Phenolics 82, 85
Polyamides (nylon) 52-53, 133, 150
Polycarbonate 131
Polyesters 85
Polyethylenes 16, 36, 133
Polypropylene 33, 36, 133, 142
Polystyrene 36, 52-53
Reinforced 122, 139, 158
Vinyls 6
Vulcanized fibre 153
Plastics moldings 30-31, 67, 163
Plating processes, solutions 50-51
Platinum metals 126-127
Precision parts, metal 132
Precoated and preplated metals 34, 48, 78-79, 134-135
Pressure vessels 126
Rayon 75
Refractory materials 18, 86-87, 168
Rings, metallic 81, 148
Roll formed parts 128
Rubber
  Moldings 64
  Silicone 124
  Synthetic 68-69, 72-73, 127
Screw machine parts 140-141, 166
Sealing alloys, ceramic-metal 146
Silicones 47, 54, 65, 119-120
Stampings, punchings 30-31, 163
Steel
  Carbon 151
  Heat and corrosion resistant 4, 138, 147
  Low alloy 71, 78-79, outside back cover
  Specialty 8, 20
  Tool and die 61
Strip, precision rolled 130
Tubing and pipe
  Metallic 22, 44, 55, 74, 78-79
  Nonmetallic 6, 157, 162
Vacuum melted metals outside back cover
Weldments 30-31
Wire 30-31, 136, 159, 166
Wire cloth 21
Wood 143

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Acheson Colloids Co 160
Jaqua Co.

Advance Tool and Die Casting Co..... 23
Ken Seitz & Associates, Inc.

***Allied Research Products, Inc**.....50, 51
Emery Advertising Corp.

***American Cast Iron Pipe Co., Acipco Steel Products Div.** 55
Robert Luckie & Co., Inc.

***American Felt Co.** .....3rd Cover
Kelly, Nason, Inc.

American Lava Corp. 57
Designers, Inc.

***American Smelting and Refining Co., Continuous Cast Dept.** 49
Ward William & Co.

***American Viscose Corp.** 75
Arndt, Preston, Chapin, Lamb & Keen, Inc.

AmForge Div., American Brake Shoe Co... 46
Fuller & Smith & Ross Inc.

Ampco Metal, Inc. 165
Hoffman, York, Paulson & Gerlach, Inc.

Anaconda American Brass Co.....2nd Cover
Kenyon & Eckhardt, Inc.

***B B Chemical Co., Bostik Dept.** 135
Sutherland-Abbott

Babcock & Wilcox Co., Tubular Products Div. 22
Marsteller, Rickard, Gebhardt and Reed, Inc.

Bethlehem Steel Co. 61, 71, 151, 159
Hazard Advertising Co., Inc.

***Branson Instruments, Inc., Ultrasonic Power Div.** 25
Faulkner Advertising Inc.

Cannon-Muskegan Corp. 81
Klau-Van Pietersom-Dunlap, Inc.

Carborundum Co., Refractories Div. 58, 59, 86, 87, 168
G. M. Basford Co.

Carwin Co. 125
Langeler-Stevens Inc.

Ceilcote Co., Inc. 158
Penn and Hamaker, Inc.

*Celanese Polymer Co., Div. of Celanese Corp. of America 145
Ellington & Co., Inc.

*Cerro Sales Corp., Sub. of Cerro Corp..... 169
Thoma & Gill

Chace, W. M., Co. 156
Clark & Boberts, Inc.

Cleveland Container Co. 162
Nesbitt Service Co.

*Colonial Rubber Co. 124
Ralph Gross Advertising, Inc.

Continental-Diamond Fibre Corp., Sub. of Budd Co. 157
Aitkin-Kynett Co., Inc.

*Continental Felt Co. 163
Daniel H. Price, Inc.

Copperweld Steel Co. 8
Bayless-Kerr Co.

*Dixon Corp. 168
Horton, Church & Goff, Inc.

Dow Corning Corp. 65, 119, 120
Church and Guisewite Advertising, Inc.

*Driver, Wilbur B., Co. 146
George Homer Martin Associates

Drop Forging Association 56
Meldrum & Fewsmith, Inc.

Du-Co Ceramics Co. 164
McHenry-Derek Advertising

*du Pont de Nemours, E. I., & Co., Inc. Elastomer Chemicals Dept. 127
N. W. Ayer & Son, Inc.

*du Pont de Nemours, E. I., & Co., Inc. Fabrics Div. 83
Batten, Barton, Durstine & Osborn, Inc.

*Duraloy Co. 154
Sanger-Funnell, Inc.

*Durez Plastics Div., Hooker Chemical Corp. 85
Rumrill Co., Inc.

Eastman Chemical Products, Inc., Plastics Div. 33
Fred Wittner Co., Inc.

Edgewater Steel Co. 148
Downing Industrial Advertising, Inc.

*Enjay Chemical Co., Div. of Humble Oil & Refining Co. 72, 73, 149
McCann-Erickson Advertising

*Epoxy Products Div., Joseph Waldman & Sons 165
Keyes, Martin & Co.

*Fiberite Corp. 139
Harold C. Walker Advertising

Foster Grant Co., Inc. 52, 53
Donahue & Coe, Inc.

Gamble Brothers, Inc. 143
Doe-Anderson Advertising Agency, Inc.

Garlock Inc. 64
Hutchins Advertising Co., Inc.

*General American Transportation Corp., Plastics Div. 67
Edward H. Weiss and Co.

General Electric Co., Chemical Materials Dept. 82, 131
G. M. Basford Co.

General Electric Co., Silicone Products Dept. 54
Ross Roy-Brooke, Smith, French & Dorrance, Inc.

*General Extrusions, Inc. 169
R. J. McCallister Co.

Goodrich, B. F., Chemical Co., Div. of B. F. Goodrich Co. 6
Griswold-Eshleman Co.

Goodrich-Gulf Chemicals, Inc.....68, 69
Ketchum, MacLeod & Grove, Inc.

Grace, W. R., & Co., Polymer Chemicals Div. 36
de Garmo, Inc.

*Graphite Specialties Corp. 140
Scheel Advertising Agency, Inc.

Gries Reproducer Corp. 164
Harold Marshall Advertising Co., Inc.

*Grip Nut Co., Sub. of Heli-Coil Corp..... 169
Ross Llewellyn Inc.

*Handy & Harman 88
Hazard Advertising Co., Inc.

*Hoeganaes Sponge Iron Corp..... 161
Norman A. Strang, Advertising

Hughson Chemical Co., Div. of Lord Manufacturing Co. 129
Jayme Organization, Inc.

*Instrument Specialties Co., Inc..... 166
George Homer Martin Associates

International Nickel Co., Inc. 4, 147
McCann-Marschalk Co., Inc.

*International Nickel Co., Inc., Platinum Metals Div. 26, 27
McCann-Marschalk Co., Inc.

La Salle Steel Co. 20
Fensholt Advertising Agency, Inc.

Lead Industries Association..... 90
O. S. Tyson and Co. Inc.

Lepel High Frequency Laboratories, Inc.... 167
Apex Graphic Co., Inc.

Linde Co., Div. of Union Carbide Corp..... 80
J. M. Mathes, Inc.

*Little Falls Alloys Inc. 166
Von der horst & Associates, Inc.

*Marbon Chemical Div., Borg-Warner Corp. 137
Holtzman-Kain Advertising

Materials in Design Engineering..... 152

Materials Selector 167

McLouth Steel Corp. 138
Denman & Baker, Inc.

*Metal & Thermit Corp. 66
Marsteller, Rickard, Gebhardt & Reed, Inc.

Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Div.... 74
MacManus, John & Adams, Inc.

Misco Precision Casting Co., Div. of Howe Sound Co. 35
Wallace-Blakeslee, Inc.

Monsanto Chemical Co., Plastics Div.....62, 63
Needham, Louis and Brorby, Inc.

Morganite Inc. 142
George Homer Martin Associates .

Mt. Vernon Die Casting Corp..... 84
Reach, McClinton & Co., Inc.

*Mueller Brass Co. 140, 141
Price, Tanner & Willox, Inc.

*Mycalex Corporation of America..... 24
Kelley, Nason, Inc.

*National Vulcanized Fibre Co..... 153
Harris D. McKinney, Inc.

*New Jersey Zinc Co.....2, 3

*Newark Wire Cloth Co..... 21
Sanger-Funnell, Inc.

*Norton Co., Refractories Div..... 18
Chirurg & Cairns, Inc.

*Oakite Products, Inc..... 155
Marsteller, Rickard, Gebhardt and Reed, Inc.

*Olin Mathieson Chemical Corp., Metals Div. 32
Doyle • Dane • Bernbach, Inc.

*Page Steel & Wire Div., American Chain & Cable Co., Inc..... 136
Reincke, Meyer & Finn, Inc.

Parker Rust Proof Co..... 48
Fred M. Randall Co.

Phillips Chemical Co., Plastics Sales Div... 16
Lambert & Feasley, Inc.

Polymer Corporation of Penna. 150
Beaumont, Heller & Sperling, Inc.

Pressed Steel Tank Co..... 126
Buchen Advertising, Inc.

Pure Carbon Co., Inc..... 60
Ellis Advertising Co.

Raybestos-Manhattan, Inc., Reinforced Plastics Dept. 122
Gray & Rogers

*Reichert Float & Mfg. Co..... 163
Wendt Advertising Agency

*Republic Steel Corp.....78, 79
Meldrum & Fewsmith, Inc.

*Rhode Island Tool Co..... 165
Horton, Church & Goff, Inc.

*Rochester Products Div., General Motors Corp. 44
D. P. Brother & Co.

Roll Formed Products Co..... 128
Meek and Thomas, Inc.

St. Joseph Lead Co. 34
Emil Mark & Co., Inc.

*St. Regis Paper Co., Industrial Panelyte Div. 76
Cunningham & Walsh Inc.

*Silicones Div., Union Carbide Corp..... 47
J. M. Mathes, Inc.

Sinko Manufacturing and Tool Co..... 163
Allen J. Siegel Advertising

*Somers Brass Co., Inc..... 130
Charles Palm & Co., Inc.

*Speer Carbon Co..... 45
Hazard Advertising Co., Inc.

Spencer Chemical Co. 133
Bruce B. Brewer & Co.

Sprayiat Corp. 70
Howard A. Harkavy, Inc.

*Superior Tube Co. 77
Gray & Rogers

Super-Temp Eng. & Mfg., Inc..... 167

*Sylvania Electric Products, Inc., Parts Div. 30, 31
Kudner Agency, Inc.

Timken Roller Bearing Co., Steel & Tube Div.....Back Cover
Batten, Barton, Durstine & Osborn, Inc.

Torrington Co., Specialties Div..... 132
Hazard Advertising Co., Inc.

United States Graphite Co.....28, 29
Price, Tanner & Willox, Inc.

United States Stoneware Co., Plastics and Synthetics Div. 14
Ralph Gross Advertising, Inc.

Vanadium-Alloys Steel Co..... 144
Downing Industrial Advertising, Inc.

Weckesser Co. 167
Symonds, Mackenzie & Co., Inc.

Wheeling Corrugating Corp.....134, 135
Cunningham & Walsh Inc.

These manufacturers advertised their products in the 1960-61

MATERIALS SELECTOR REFERENCE DATA ISSUE

For more complete information, and application data on their lines, refer to the index of Advertisers in the Mid-November MATERIALS SELECTOR ISSUE of MATERIALS IN DESIGN ENGINEERING.

THE LAST WORD

by H. R. Clauser
Editor

Should They Take Off the Gloves?

A few months ago, at a press conference, the president of a steel company announced: "Now we are taking our gloves off, too." This action was precipitated, he said, by the aluminum industry's unjustified attacks against the qualifications of steel for automobile bumpers. Another "battle" is now raging between acetal moldings and zinc die castings. Statements such as "acetal resin is a replacement for die cast metals" and "die castings are superior to plastic moldings" are typical of those being heard in this controversy.

These two are the most publicized of the current battles between materials producers. But there have been and are many others. And as more and more new materials are developed and as competition for markets grows, more of these kinds of battles can be expected.

Real or Pseudo-Battles?

But are these real or are they just pseudo-battles? To the producers, they are very real indeed. But to end users, they are often unimportant skirmishes consisting of big puffs and noises that bear little relation to their particular problems.

Thus, when a producer glows in print over the adoption of his material for a glamorous or a large volume application, the materials user does not necessarily respond in kind. For, he knows that the example merely demonstrates the material's satisfactory performance in that particular product, not in all products, and not even in products of a similar nature. Likewise, broad claims and general comparisons between two or more "rival" materials leave the materials-using engineer cold.

In the Old Days

In the past there was, perhaps, more reason for these all-out competitive battles. Engineers were far less knowledgeable about materials and could be more easily influenced. Also, they tended to fit their designs to the materials with which they were most familiar. Now, they are more sophisticated where materials are concerned. Also, the increasing number of technical people and departments who are spending full time on materials application problems are adept at penetrating promotional smoke screens. They are much less interested in general claims and blanket comparisons than in finding and applying the material that will best meet the service, manufacturing and cost requirements.

With this approach, then, each application is unique. And, likewise, each material and each material form has a unique set of properties. Many materials producers are already aware of the new attitude and the modern approach to materials application. But many are not. Those who are, are adopting the more fruitful policy of developing new materials or modifying old ones, not to compete with other materials but rather to provide certain sets of performance properties. If and when this approach is more widely adopted, there will be fewer "battles" and more victories for intelligent materials application.

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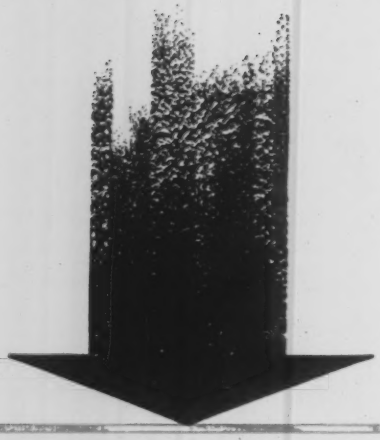

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